Benthic TMDL Development Report for the Sediment Stressor

Moores Creek, Lodge Creek, Meadow Creek, and Schenks Branch

Albemarle County and Charlottesville City, Virginia

Submitted by:

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Draft: August 20, 2012

VT-BSE Document No. 2011-0007

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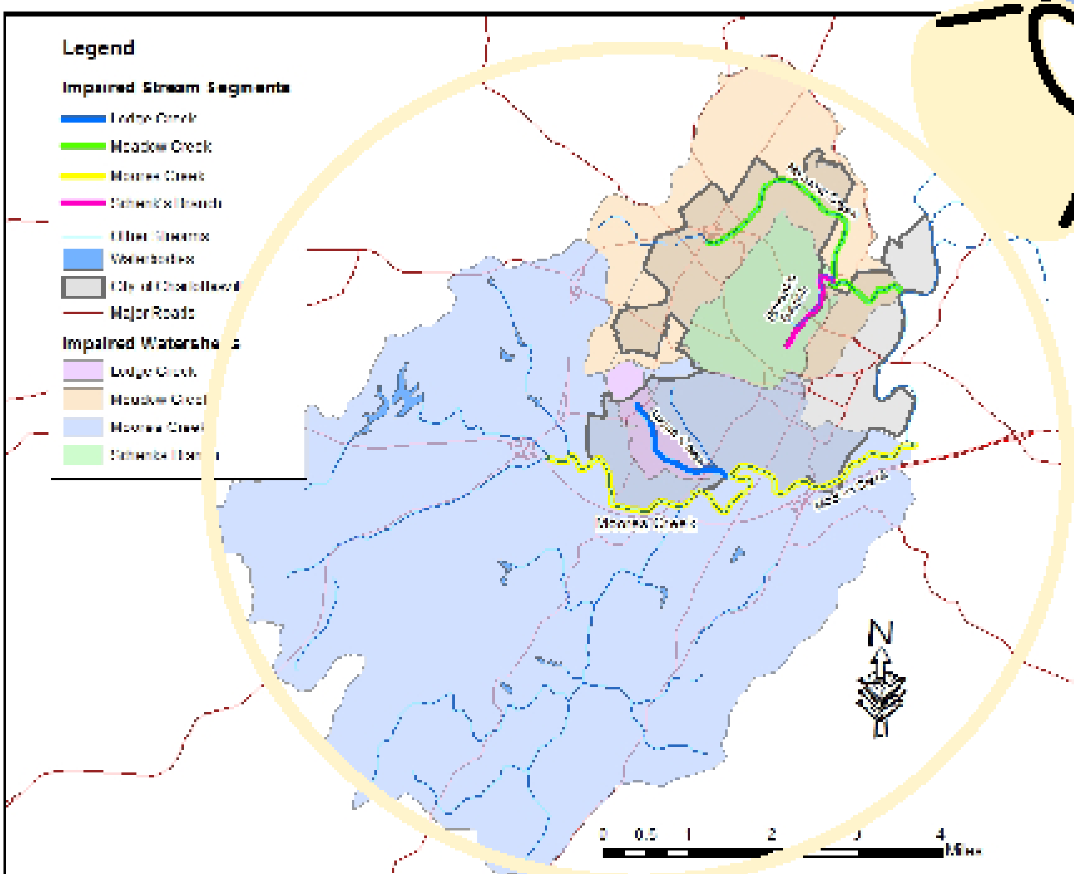
List of Acronyms

BMP	Best Management Practices
BSE	Biological Systems Engineering
COD	Chemical Oxygen Demand
DCR	Virginia Department of Conservation and Recreation
DEQ	Virginia Department of Environmental Quality
DO	Dissolved Oxygen
E&S	Erosion and Sediment Control Program (DCR)
GIS	Geographic Information Systems
LA	Load Allocation
MDL	Minimum Detection Limit
MFBI	Modified Family Biotic Index
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System program (EPA)
NASS	National Agricultural Statistics Service (USDA)
NLCD	National Land Cover Dataset
NPS	Non-Point Source
NRCS	Natural Resources Conservation Service (USDA)
PEC	Probable Effect Concentrations
PReP	Pollution Response Program (DEQ)
RBP	Rapid Bioassessment Protocol
RRBC	Rivanna River Basin Commission
SSO	Sanitary sewer overflow
STP	Sewage treatment plant
TAC	Technical Advisory Committee
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorous
TSS	Total Suspended Solids
UAL	Unit-area load, e.g. lbs/acre
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
VSCI	Virginia Stream Condition Index
VDOT	Virginia Department of Transportation
VPDES	Virginia Pollutant Discharge Elimination System
VSMP	Virginia Stormwater Management Program (DCR)
VT	Virginia Tech
WIP	Watershed Implementation Plan
WLA	Waste Load Allocation

SPOTLIGHT ON LOCAL STREAMS:

Summary Report on Lodge Creek, Moores Creek, Schenks Branch and Meadow Creek



Lodge Creek, Moores Creek, Schenks Branch and Meadow Creek Watersheds

The Virginia Department of Environmental Quality (VADEQ) monitors the Commonwealth's streams and rivers (*there are 52,232 miles of them!*) for five uses: fishing, swimming, wildlife, aquatic life (benthic), and drinking. When streams fail to meet standards based on these uses, they are declared to be "impaired", or not fully supportive of their beneficial uses, and placed on Virginia's impaired waters list. Based on routine water quality monitoring, four streams in Charlottesville and Albemarle County have been added to the list of waterways in Virginia that do not meet water quality standards. VADEQ reports this list to the USEPA every other year in the "*305(b)/303(d) Water Quality Assessment Integrated Report*" as required by the federal Clean Water Act of 1972. Moores Creek and its tributary, Lodge Creek, were originally listed as impaired on Virginia's in 2008 and 2006, respectively, due to violations of the general aquatic life standard. Meadow Creek and its tributary, Schenks Branch, were originally listed as

Are we being singled out? No. In Virginia, 68% of assessed streams are considered "impaired".

impaired in the same reports in 2006 and 2008, respectively, also due to violations of the general aquatic life standard. A **Total Maximum Daily Load** must be prepared for streams that do not meet water quality standard and are listed as impaired.

Total Maximum Daily Load

A TMDL is a pollution budget for a stream, which sets a maximum amount of a pollutant that can be released into a stream but still allows the stream to maintain water quality standards. It is also the process of improvement that Virginia uses to make streams healthier and cleaner. This report is part of the TMDL studies for these streams.

What is the general aquatic life water quality standard? What does benthic mean?
The basis of a stream's food chain is found in the community of the aquatic organisms that live at the bottom of the stream, known as benthic (or bottom-dwelling) macroinvertebrates (organisms without backbones that can be seen with the naked eye). These bugs are important because they are a key food source for other organisms, they play an important role in the cycling of nutrients, and they are good indicators of pollutants. The aquatic life water quality standard states that all state waters should support a healthy and diverse community of invertebrates and fish. Based on VADEQ's and StreamWatch biological monitoring results, it was concluded that segments of Lodge Creek, Moores Creek, Schenks Branch and Meadow Creek were not meeting this standard. Here are a few examples of benthic macroinvertebrates (all images courtesy of Bob Hendricks).

From Left to Right: Dragonfly larvae, Stonefly nymph, caddisfly larvae, flathead mayfly larvae.

Why don't these streams support a healthy aquatic community? After reviewing various types of data and examining possible stressors in the aquatic habitat, VADEQ and its Technical Advisory Committee identified the primary stressor on the aquatic community in each stream to be sediment. **Sediment** is soil that has been washed off the land during rain storms and soil that is scoured from the stream banks by fast moving water. Development has changed the way rainwater moves over land and through stream channels. Impervious surfaces have a negative impact on water quality because these surfaces, like pavement, rooftops and sidewalks, do not allow precipitation to slowly infiltrate into the soil.

Stormwater conveyance in a parking lot. (Credit: VADEQ)

How does pavement hurt streams? Instead of naturally allowing rainwater to infiltrate into the soil, impervious surfaces quickly move it into conveyance structures, like storm drains or storm sewers, or directly into streams and rivers. This is known as **stormwater runoff** and impacts streams in a multitude of ways. Stormwater is a problem because it washes pollutants like **sediment** from construction sites, oil from vehicles, nutrients from fertilized yards, and bacteria from pet waste into streams and rivers. Also, stormwater increases the flow in streams after a precipitation event, which can result in scouring of sediment from exposed streambanks, and often adds to the problem. **Stormwater runoff** – how it travels and what it carries– is affected by the landscape, or land use of the watershed. For example, when it rains in a forested area, the rain is slowed by the leaves of the trees and it infiltrates into the ground quickly. The landscape for these four watersheds is summarized by general categories in the below table. Urban land uses dominate the Lodge Creek, Schenks Branch, and Meadow Creek watersheds, ranging between 83% and 96%, while forest is the dominant land use in Moores Creek (61%).

Land Use Group	Lodge Creek	Moores Creek **	Schenks Branch	Meadow Creek **
	Area in acres			
Cropland	0.0	70.3	0.0	7.3
Pasture/Hay	0.0	980	0.0	44.3
Urban Pervious	287.0	5,652.3	878.3	2,335.1
Urban Impervious	144.3	1,630.9	474.6	1,339.9
Forest	50.4	13,294.5	53.4	664.8
Water	0.0	232.4	1.9	19.0
Total	481.7	21,860.5	1,408.1	4,410.4
** Moores Creek excludes Lodge Creek; Meadow Creek excludes Schenks Branch				
Land Uses in these watersheds are from the 2009 Rivanna and Vicinity Land Use/Land Cover Map and the 2009 National Agricultural Statistics Service.				

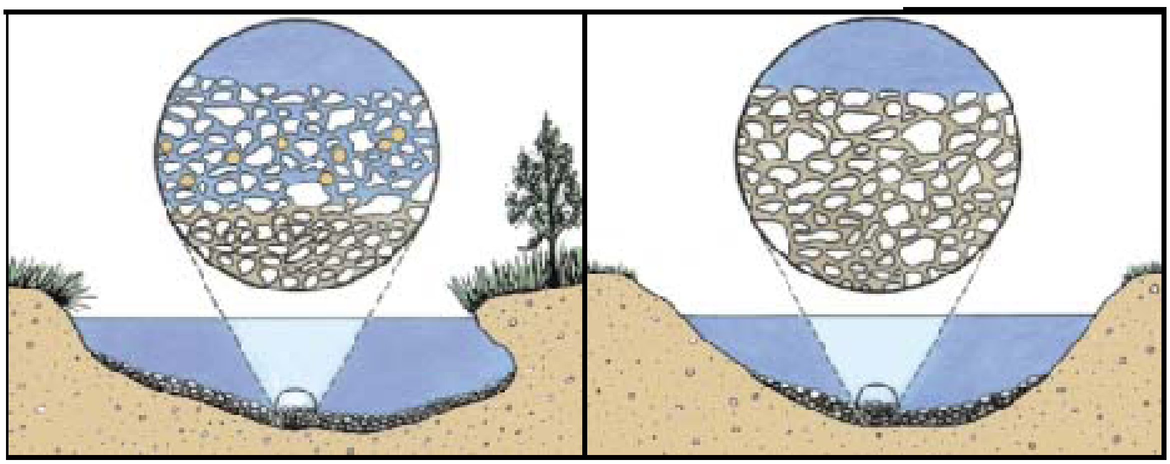
Sources of sediment are typically divided into two categories - **point** and **nonpoint sources**. The sediment in the watersheds for the four impaired streams involved in this project comes primarily from nonpoint source pollution including urban land, agricultural land, and stream channel erosion. Impervious urban areas (roads, parking lots, roof tops) collect atmospheric dust and dirt which are

NONPOINT Sources of pollution are those from diffuse areas with no single point of entry to a waterway (streets, sidewalks). POINT Sources of pollution are from a definitive point or outfall (a pipe from a factory).

then washed off during storms. Development activity (building roads, houses and other buildings) can contribute sediment to waterways if proper controls are not in place. Agricultural lands, such as cropland and pasture/hay areas, often contribute excessive sediment loads through basic erosion of areas with reduced vegetative coverage. Point sources in these four watersheds are limited. One such source is the Moores Creek Wastewater Treatment Plant which discharges, according to its permit limits, a minor amount of sediment.

Point Source vs. Non-point Source (Credit: VADEQ – Jeffries and Harrigan)

Why is too much sediment in a stream system a problem? Aquatic organisms need space in between rocks and gravels on the stream bottom in order to make their homes, move, and capture prey. With too much sediment, the niches in between the rocks are filled in, it's difficult to travel, and food sources are eliminated. Below is an illustration of a healthy stream bed versus one with extra sediment.

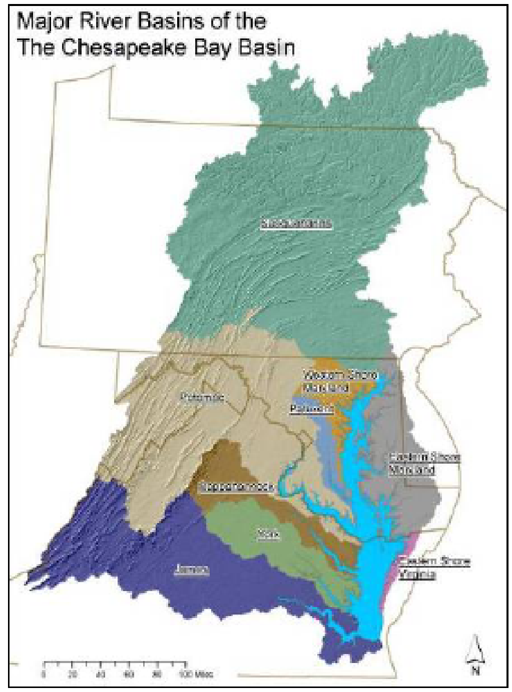


What is being done? ***(And what, really, is a TMDL?)*** VADEQ and its local and state agency partners have been working together since 2010 to determine sources of the sediment, suggest reductions, and recommend next steps in the process known as the **Total Maximum Daily Load (TMDL)** process. In these **TMDL** studies for Lodge Creek, Moores Creek, Meadow Creek and Schenks Branch, a watershed-based approach was used to relate both land-based and in-stream sources of pollutants to water quality problems. In order to develop a **TMDL**, background pollutant concentrations, point source contributions, and non-point source contributions are considered. Through the

WHAT IS A WATERSHED? It's an area of land that drains to a common point or body of water.

TMDL process, states are able to identify water-quality based controls to reduce pollution and meet water quality standards.

How do the local stream TMDLs relate to the Chesapeake Bay TMDL? These local TMDLs are based on monitoring of local stream and have been developed to identify the sediment reductions needed in order for these streams to support a healthy and diverse population of aquatic life. The Chesapeake Bay TMDL was developed using monitoring data collected within the Chesapeake Bay watershed which consists of six states and the District of Columbia. It has been developed to identify the nitrogen, phosphorous and sediment reductions needed to restore the water quality in the Chesapeake Bay. The Chesapeake Bay itself is downstream from the Charlottesville and Albemarle County's local streams and their watersheds. As such, these local watersheds are components of the larger watershed that drains into the Chesapeake Bay, meaning that whatever enters local streams eventually enters the Chesapeake Bay. Conversely, any pollutant reductions to local streams also reduce pollutant loading to the Bay. While these TMDL studies for Lodge Creek, Moores Creek, Schenks Branch and Meadow Creek are focused on how to reduce sediment entering these streams, the measures taken to reduce sediment will also result in reductions of both nitrogen and phosphorus transported to the streams. Therefore, all best management practices and pollutant reductions from these local TMDLs also contribute to the reductions needed to meet Chesapeake Bay cleanup goals.



Whatever we do to clean up our local streams will also help downstream.

So, what reductions are recommended? The table below summarizes the reductions that need to be made from the average amount of sediment that currently comes into the streams from each watershed, the target amount of sediment and the percent reduction that this calls for.

NOTE: One dump truck load = about 20 tons of sediment.

That's 160 dump truck loads moving down Moores Creek every year!

	Lodge Creek	Moores Creek	Schenks Branch	Meadow Creek
Avg. Yearly Load	**184.8 tons/yr**	**3,008.9 tons/yr**	**619.6 tons/yr**	**1,264.3 tons/yr**
Target Yearly Load	**152.6 tons/yr**	**2,604.5 tons/yr**	**500.2 tons/yr**	**1346.5 tons/yr**
% Reduction	**17.4%**	**15.8%**	**19.3%**	**-6.5%**

Where do these reductions come from? There are many reasons to decrease the amount of sediment coming into streams and rivers. Not only will the aquatic habitat which is the foundation of a stream's food chain be restored, but water treatment and stormwater

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management costs can be reduced. When more soil is kept on the land, the soil is able to maintain its fertility and productivity. The recommended reductions can be accomplished by installing stormwater management practices to prevent sediment from getting into the streams. Techniques that target the land uses that contribute the most sediment will be most effective. With that in mind, the below table summarizes the three land uses that contribute the most sediment in each of the four watersheds.

Lodge Creek, Moores Creek, Schenks Branch, Meadow Creek Land Uses	**Examples of this Land Use**
Impervious surfaces	**Parking lots, roads, roofs, sidewalks**
Pervious surfaces	**Lawns, parks, fields, grassed areas**
Construction	**Building lots, exposed topsoil**

What's next? The goal of the **TMDL** program is to establish a three-step path that will lead to attainment of water quality standards. The first step in the process is to develop **TMDLs** that will result in meeting water quality standards, which is a federal mandate under the Clean Water Act. This report represents the culmination of that effort for the benthic impairments in Lodge Creek, Moores Creek, Schenks Branch, and Meadow Creek. The second step, mandated by Virginia law, is to develop a **TMDL Implementation Plan**. The final step is to implement this plan and to monitor stream water quality to determine if water quality standards are being attained. Implementation of these **TMDLs** will contribute to on-going water quality improvement efforts in these four watersheds. Ongoing restoration efforts include the Meadow Creek Stream Restoration project which is being coordinated with a Rivanna Water and Sewer Authority project to upgrade a Sanitary Sewer Interceptor along the stream; existing stormwater management programs in Albemarle County, the City of Charlottesville, the University of Virginia, and along VDOT properties; incorporation of urban infiltration practices, such as the rain garden at Greenleaf Park and retrofitting green roofs on existing municipal buildings, such as the Charlottesville City Hall and the Police Building. In addition, efforts will be made to learn from, and coordinate with, other existing TMDLs for bacteria and sediment in the Rivanna River Basin and the Moores Creek Bacteria TMDL Implementation Plan.

Greanleaf Park Rain Garden
(Credit: City of Charlottesville)

Want more information or to be involved in the next step? Contact Kristel Riddervold, Environmental Administrator for Charlottesville, at riddervold@charlottesville.org. Contact Greg Harper, Water Resources Manager for Albemarle County, at gharper@albemarle.org. Also, check out these links to find out more information on the TMDL Program, local stream improvement efforts, and community organizations that are already working in your area!

www.deq.virginia.gov/tmdl www.rivannariverbasin.org www.rivannariver.org
www.rivanna-stormwater.org http://www.epa.gov/chesapeakebaytmdl/

CHAPTER 1: INTRODUCTION

1.1. Background

1.1.1. TMDL Definition and Regulatory Information

Section 303(d) of the Federal Clean Water Act and the U.S. Environmental Protection Agency's (USEPA) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to identify water bodies that violate state water quality standards and to develop Total Maximum Daily Loads (TMDLs) for such water bodies. A TMDL reflects the pollutant loading a water body can receive and still meet water quality standards. A TMDL establishes the allowable pollutant loading from both point and nonpoint sources for a water body, allocates the load among the pollutant contributors, and provides a framework for taking actions to restore water quality.

1.1.2. Impairment Listing

The subjects of this TMDL study are impaired stream segments along Moores Creek and its tributary, Lodge Creek, and along Meadow Creek and its tributary, Schenks Branch. These four impaired segments are located within the Rivanna River Basin and straddle the boundary between the City of Charlottesville and Albemarle County in the Commonwealth of Virginia, as shown in Figure 1-1.

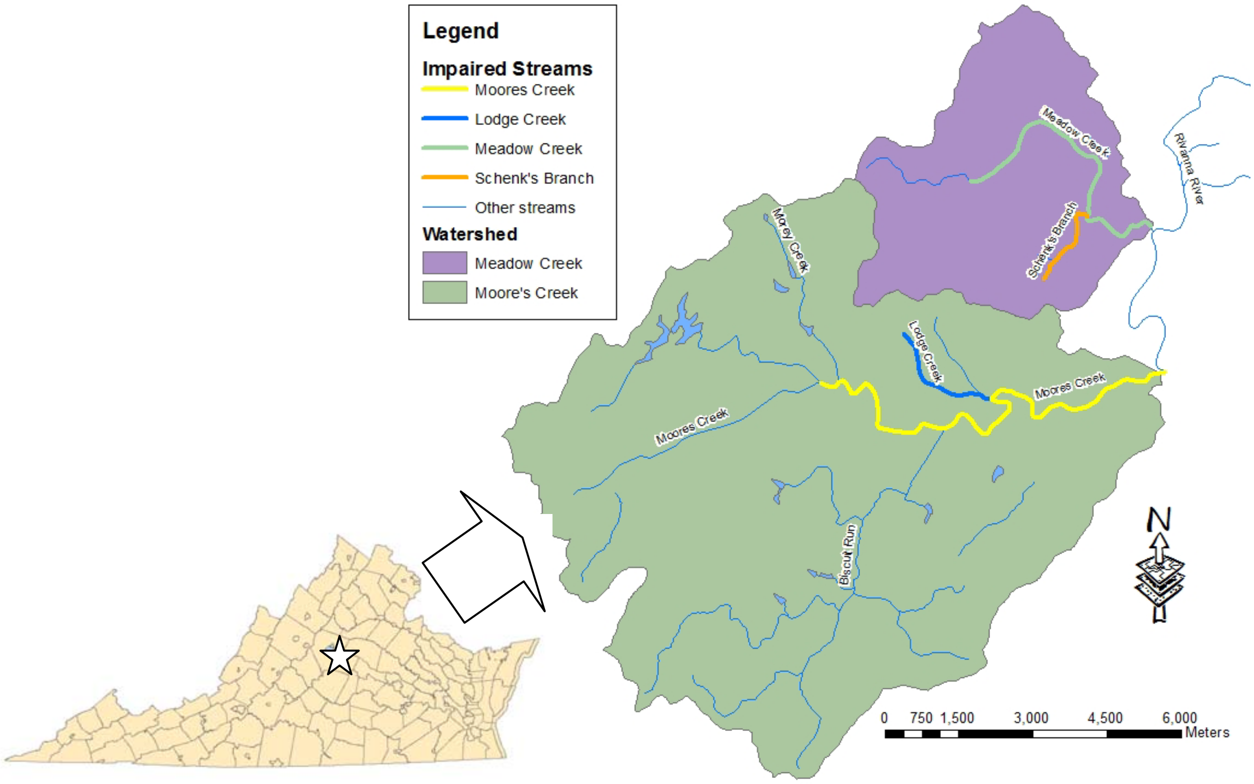

Figure 1-1. Location of Impaired Segments and Major Watersheds

Moores Creek and its tributary, Lodge Creek, were originally listed as impaired on Virginia's 2008 and 2006 305(b)/303(d) Water Quality Assessment Integrated Reports, respectively, due to water quality violations of the general aquatic life (benthic) standard. Meadow Creek and its tributary, Schenks Branch, were originally listed as impaired in the same reports in 2006 and 2008, respectively, also due to water quality violations of the general aquatic life (benthic) standard.

The Virginia Department of Environmental Quality (DEQ) has delineated the benthic impairment as 6.37 miles on Moores Creek, extending from its confluence with the Ragged Mountain Reservoir receiving stream, downstream to its confluence with the Rivanna River. The DEQ 2010 Fact Sheets for Category 5 Waters (VADEQ, 2010) state that Moores Creek was impaired based on assessments at DEQ biological station 2-MSC000.60 and citizen monitoring station, 2-MSC-MSC04-SW. The sources of impairment were listed as "Municipal (Urbanized High Density Area)" and "Non-Point Source".

DEQ delineated a benthic impairment on an unnamed tributary to Moores Creek, listed as 1.57 miles. The “unnamed tributary” is known locally as Lodge Creek, but also contains a portion of Rock Creek. The impaired segment extends 1.37 miles from the headwaters of Lodge Creek to its confluence with Rock Creek and along a 0.20 mile segment of Rock Creek down to its confluence with Moores Creek. This impaired segment will be referred to as Lodge Creek for the remainder of this report. The Lodge Creek watershed is a sub-watershed of the Moores Creek watershed. The DEQ 2010 Fact Sheets for Category 5 Waters (VADEQ, 2010) state that this segment was impaired based on assessments at DEQ biological station 2-XRC001.15 and citizen monitoring station, 2-XRC-XRC01-SW, with the impairment attributed to “Non-Point Source”.

The benthic impairment on Meadow Creek was delineated as 4.0 miles, extending from its headwaters to its confluence with the Rivanna River. The DEQ 2010 Fact Sheets for Category 5 Waters (VADEQ, 2010) cite Meadow Creek as being impaired based on assessments at DEQ biological station 2-MWC000.60 and at citizen monitoring stations 2-MWC-MWC01-SW and 2-MWC-MWC03-SW. The source of impairment in Meadow Creek was stated as “Non-Point Source.”

The benthic impairment on Schenks Branch extends 1.13 miles from its headwaters downstream to its confluence with Meadow Creek. Schenks Branch watershed is a sub-watershed of the Meadow Creek watershed. The DEQ 2010 Fact Sheets for Category 5 Waters (VADEQ, 2010) state that Schenks Branch was impaired based on assessments at DEQ biological stations 2-SNK000.88, 2-XSN000.08 and 2-XSN000.18, and citizen monitoring stations 2-SNK-SHK02-SW and 2-SNK-SHV01-SW. The sources of impairment in Schenks Branch were considered to be “Municipal (Urbanized High Density Area)” and “Non-Point Source”.

1.1.3. Pollutants of Concern

Pollution from both point and nonpoint sources can lead to a violation of the benthic standard. A violation of this standard is assessed on the basis of measurements of the in-stream benthic macro-invertebrate community. Water bodies having a benthic impairment are not fully supportive of the aquatic life designated use for Virginia's waters.

1.2. Designated Uses and Applicable Water Quality Standards

1.2.1. Designation of Uses (9 VAC 25-260-10)

> "A. All state waters are designated for the following uses: recreational uses (e.g. swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)." SWCB, 2010.

1.2.2. General Standard (9 VAC 25-260-20)

The general standard for a water body in Virginia is stated as follows:

> "A. All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life.
>
> Specific substances to be controlled include, but are not limited to: floating debris, oil scum, and other floating materials; toxic substances (including those which bioaccumulate); substances that produce color, tastes, turbidity, odors, or settle to form sludge deposits; and substances which nourish undesirable or nuisance aquatic plant life. Effluents which tend to raise the temperature of the receiving water will also be controlled." SWCB, 2010.

The biological monitoring program in Virginia that is used to evaluate compliance with the above standard is run by the Virginia Department of Environmental Quality (DEQ). Evaluations of monitoring data from this program focus on the benthic (bottom-dwelling) macro (large enough to see) invertebrates (insects, mollusks, crustaceans, and annelid worms) and are used to determine whether or not a stream segment has a benthic impairment. Changes in water quality generally result in alterations to the quantity and diversity of the benthic organisms that live in streams and other water bodies. Besides being the major intermediate constituent of the aquatic food chain, benthic macro-invertebrates are "living recorders" of past and present water quality conditions. This is due to their relative immobility and their variable resistance to the diverse contaminants that are introduced into streams. The community structure of these organisms provides the basis for the biological analysis of water quality. Qualitative and semi-quantitative biological monitoring have been conducted by DEQ since the early 1970's. The U.S. Environmental Protection Agency's (USEPA) Rapid Bioassessment Protocol (RBP) II was employed beginning in the fall of 1990 to utilize standardized and repeatable assessment methodology. For any single sample, the RBP II produces water quality ratings of "non-impaired," "slightly impaired," "moderately impaired," or "severely impaired." In Virginia, benthic samples are typically collected and analyzed twice a year in the spring and in the fall.

The RBP II procedure evaluates the benthic macro-invertebrate community by comparing ambient monitoring "network" stations to "reference" sites. A reference site is one that has been determined to be representative of a natural, non-impaired water body. The RBP II evaluation also accounts for the natural variation noted in streams in different eco-regions. One additional product of the RBP II evaluation is a habitat assessment. This is a stand-alone assessment that describes bank condition and other stream and riparian corridor characteristics and serves as a measure of habitat suitability for the benthic community.

Beginning in 2006, DEQ switched their bioassessment procedures. While the RBP II protocols were still followed for individual metrics, a new index, the Virginia Stream Condition Index (VSCI), was developed based on comparison of observed data to a set of reference conditions, rather than with data from a reference station. The new index was also calculated for all previous samples in order to better assess trends over time.

Determination of the degree of support for the aquatic life designated use is based on biological monitoring data and the best professional judgment of the regional biologist, relying primarily on the most recent data collected during the current 5-year assessment period. In Virginia, any stream segment with an overall rating of "moderately impaired" or "severely impaired" is placed on the state's 303(d) list of impaired streams (VADEQ, 2002).

CHAPTER 2: WATERSHED CHARACTERIZATION

2.1. Water Resources

Four watersheds are separately described in this study: Moores Creek, Lodge Creek, Meadow Creek, and Schenks Branch, each with portions of its area within both Albemarle County and the City of Charlottesville, Virginia.

The Moores Creek watershed (22,331.0 acres) comprises the 12-digit hydrologic unit JR15 and includes the Lodge Creek sub-watershed (471.4 acres), while the Meadow Creek watershed (5,818.7 acres) is in the headwater portion of hydrologic unit JR14 and includes the Schenks Branch sub-watershed (1,408.1 acres). All four watersheds are components of the HUC5 watershed, H28. These watersheds include portions of the City of Charlottesville and Albemarle County, Virginia, and are part of the Rivanna River basin. The combined watersheds are 28,150.6 acres (11,392.4 ha) in size. Lodge Creek is tributary to Moores Creek, and Schenks Branch is tributary to Meadow Creek, and both Moores Creek and Meadow Creek are tributaries to the Rivanna River, eventually flowing into the James River and the Chesapeake Bay. The locations of the study watersheds are shown in Figure 2-1.

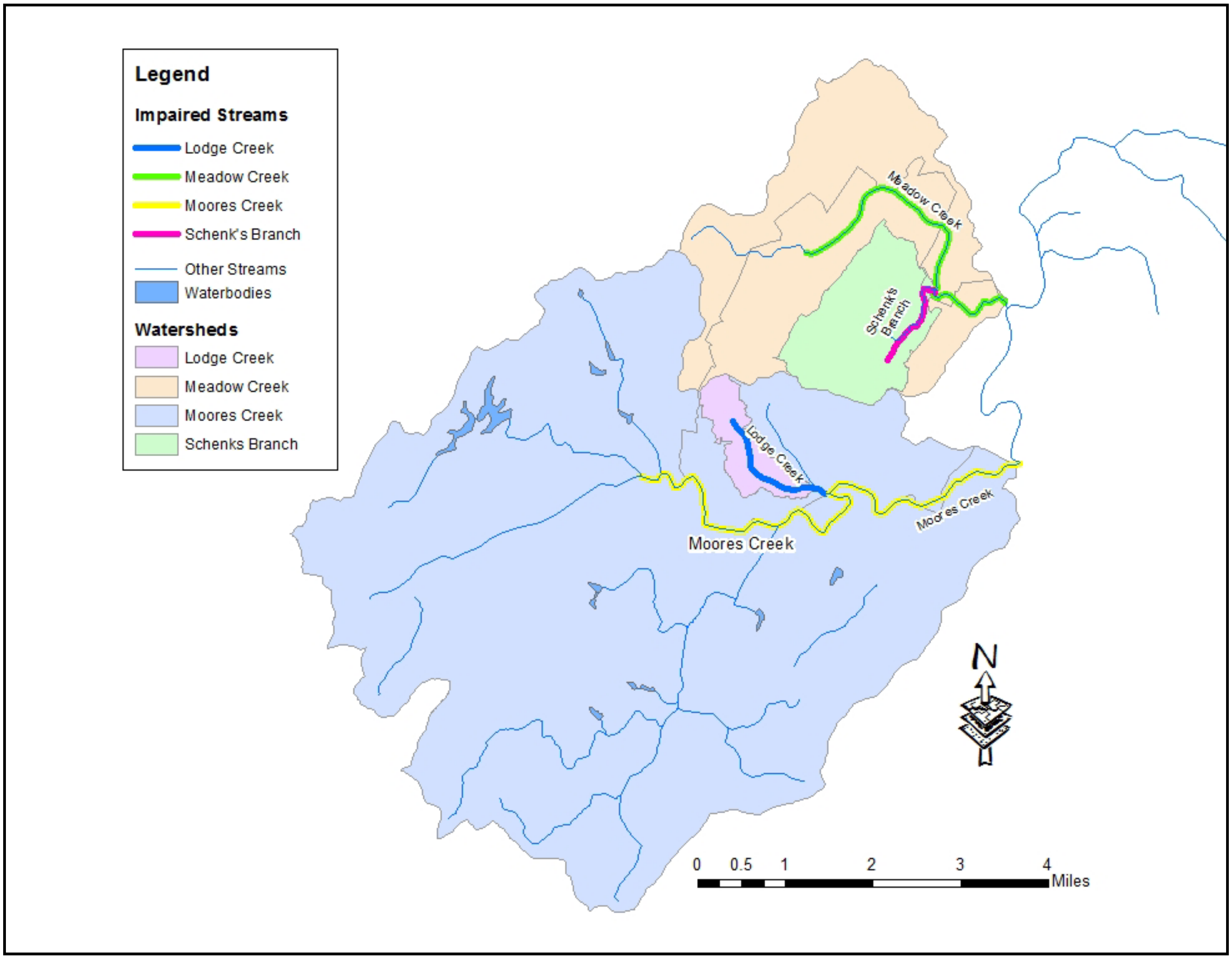

Figure 2-1. Moores Creek, Lodge Creek, Meadow Creek, and Schenks Branch Watersheds

2.2. Eco-region

The Moores Creek, Lodge Creek, Meadow Creek and Schenks Branch watersheds are located entirely within the Piedmont Upland sub-division of the Northern Piedmont ecoregion. The Northern Piedmont is a transitional region of low rounded hills, irregular plains, and open valleys in contrast to the low mountains of ecoregions to the north and west and the flat coastal plains of the ecoregion to the east. The natural vegetation in this ecoregion is predominantly Appalachian oak forest as compared to the mostly oak-hickory-pine forests of the Piedmont ecoregion to the southwest (USEPA, 2002).

2.3. Soils and Geology

The soils found in Moores Creek, Lodge Creek, Meadow Creek and Schenks Branch watersheds are primarily in the Chester, Cullen, Culpeper, Elioak, Hayesville, Hazel and Rabun series. These series form various complexes, many with rock outcrops. The Chester series of lesser extent (fine-loamy, mixed, semiactive, mesic Typic Hapludults) consists of very deep and well drained soils on uplands. These soils formed in materials weathered from micaceous schist. The Cullen series (Very-fine, kaolinitic, thermic Typic Hapludults) consists of very deep, well drained soils of moderate permeability that are formed in residuum from mixed mafic and felsic crystalline rocks. The Culpeper series (Fine, kaolinitic, mesic Typic Hapludults) consists of very deep, well drained soils. These soils are formed in arkosic metasandstones, meta-arkose and metagraywacke and are on summits, shoulders and backslopes of ridges in the foothills of the Blue Ridge Mountains. The Elioak series (Fine, kaolinitic, mesic Typic Hapludults) consists of very deep, well drained, moderately permeable soils on uplands. These soils are formed in materials weathered from micaceous crystalline rocks. The Hayesville series (Fine, kaolinitic, mesic Typic Kanhapludults) consists of very deep, well drained soils on gently sloping to very steep ridges that are formed in residuum weathered from igneous and high-grade metamorphic rocks. The Hazel series (Coarse-loamy, mixed, active, mesic Typic Dystrudepts) consists of moderately deep and excessively drained soils that are formed on uplands in material weathered dominantly from sandstone and phyllites. The Rabun series (Fine, kaolinitic, mesic Typic Rhodudults) consists of deep, well drained soils that are formed in residuum weathered from dark colored rock high in ferromagnesium minerals (USDA-NRCS, 2010).

2.4. Climate

Climate data for the Moores Creek, Lodge Creek, Meadow Creek and Schenks Branch watersheds were based on meteorological observations made at the Charlottesville 2W Climatic Data Center station (441593) located within the Albemarle County portion of the Moores Creek watershed. Average annual precipitation at this station is 48.87 inches. Average annual daily temperature at the station is 57°F. The highest average daily temperature of 78°F occurs in July while the lowest average daily temperature of 35°F occurs in January, as reported in the 1971-2000 climate normals (NCDC-NOAA, 2010).

2.5. Land Use

Land uses for the Moores Creek, Lodge Creek, Meadow Creek, and Schenks Branch watersheds were derived from the 2009 Rivanna River Basin Commission's Rivanna Watershed and Vicinity Land Use/Land Cover Map geodatabase (RRBC, 2009) and the 2009 National Agricultural Statistics Service cropland data layer (NASS, 2009). In general, the RRBC land use data were used as the primary source. In the Albemarle County portions of each watershed, the NASS cropland categories were considered refinements of the RRBC "Open Land" category, and the four NASS urban development categories were used to interpret forest cover in those areas as pervious urban areas. Additionally, the RRBC "Open Land" and "Impervious" land use categories were used to represent the pervious and impervious portions of urban/residential areas. The 10 land use categories from the RRBC and the 6 cropland and 4 urban development categories from NASS were grouped into the 11 categories summarized in Table 2-1. The RRBC categories of land uses are shown in Figure 2-2.

Table 2-1. RRBC/NASS Land Use Summary

Land Use Group	Lodge Creek	Moores Creek*	Schenks Branch	Meadow Creek*
	Area in acres			
Conventional Tillage - no manure	0.0	60.6	0.0	0.0
All Other Row Crops	0.0	10.3	0.0	7.3
Hay	0.0	781.5	0.0	31.6
Pasture	0.0	207.5	0.0	13.0
Low Density Residential - pervious	244.7	5,311.0	713.4	1,915.6
Low Density Residential - impervious	100.4	1,265.5	262.7	747.3
High Density Residential - pervious	29.6	358.2	154.2	406.2
High Density Residential - impervious	46.3	389.5	222.3	609.1
Forest	50.4	13,223.3	53.7	661.6
Harvested Forest	0.0	20.7	0.0	0.0
Water	0.0	232.4	1.9	19.0
Total	471.4	21,860.5	1,408.1	4,410.6

* Moores Creek excludes Lodge Creek; Meadow Creek excludes Schenks Branch.

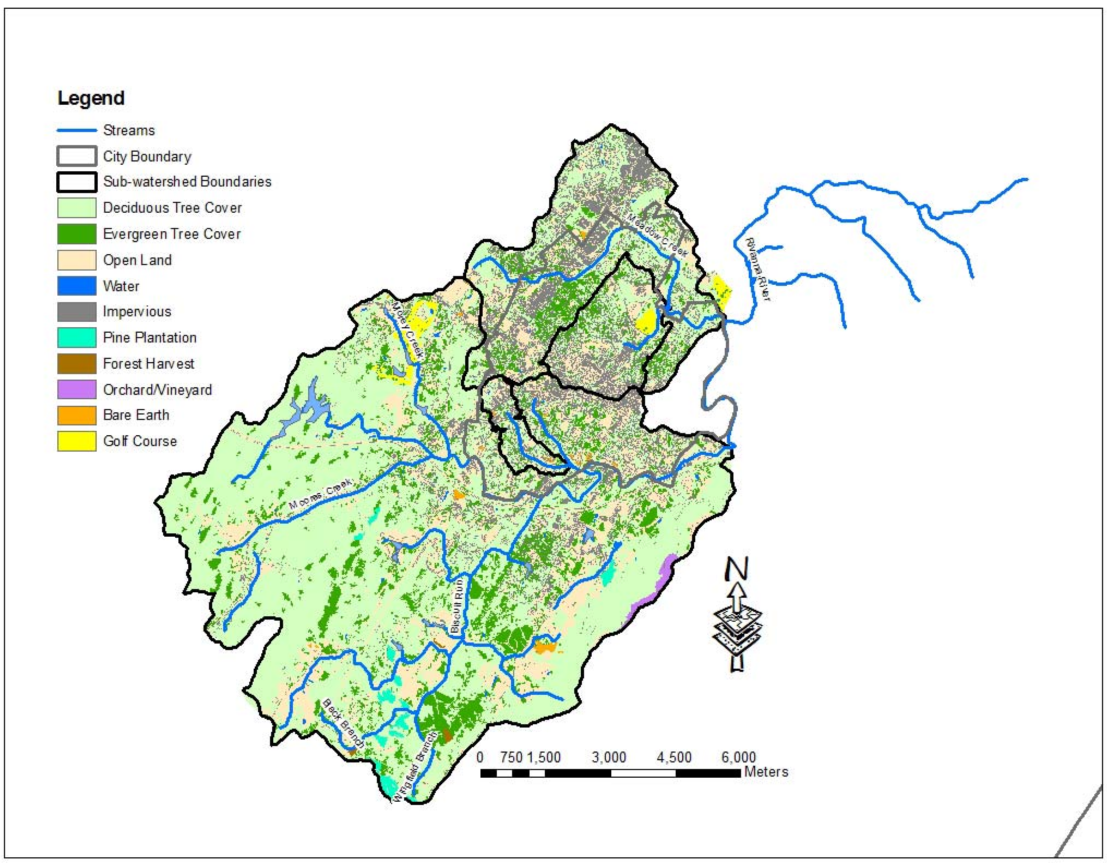

Figure 2-2. RRBC 2009 Land Use in the Moores Creek, Lodge Creek, Meadow Creek, and Schenks Branch Watersheds

2.6. Biological Monitoring Data

Biological monitoring consisted of sampling the benthic macro-invertebrate community along with corresponding habitat assessments. The data for the bioassessments in Moores Creek, Lodge Creek, Meadow Creek and Schenks Branch were based on DEQ biological monitoring at the six DEQ monitoring sites and various citizen monitoring data from the Save Our Streams and StreamWatch organizations in the watershed. One primary biological monitoring station was located in each of the four watersheds, supplemented with additional sampling at two points on an unnamed tributary to Schenks Branch. The primary biological stations were variably monitored between 2 and 5 times each during the period 2002 – 2009. The locations of the DEQ biological and ambient monitoring stations in these watersheds are shown in Figure 2-3, together with the major tributary sub-watersheds.

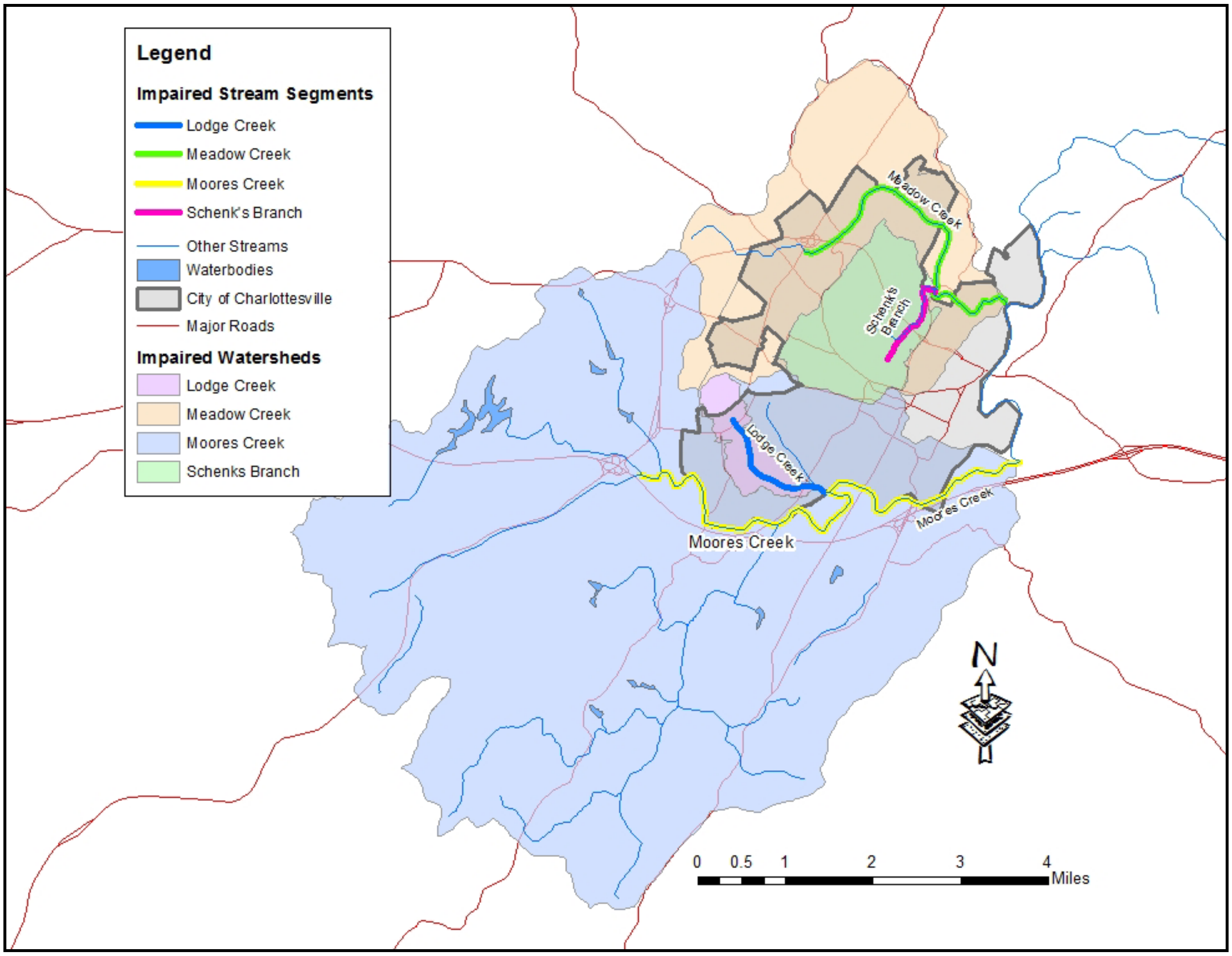

Figure 2-3. Locations of DEQ Monitoring Stations in Moores Creek, Lodge Creek, Meadow Creek, and Lodge Creek Watersheds

Biological samples were collected from a cross-section of the stream channel and from both pool and riffle environments. The organisms in each sample were separated out into identifiable family or species, and then a count was made of the number of organisms in each taxa. A full listing of the benthic macroinvertebrate taxa inventory or distribution within each biological sample is given for Moores Creek and Lodge Creek in Table 2-2, and for Meadow Creek and Schenks Branch in Table 2-3.

Table 2-2. Taxa Inventory by Sample Date in Moores Creek (MSC) and Lodge Creek (XRC)

				Moores Creek		Lodge Creek			
Taxa	Tolerance Value	Functional Family Group	Habit	2-MSC000.60		2-XRC001.15			
				10/26/06	03/20/08	04/29/02	10/16/02	04/21/04	09/30/09
Tipulidae	3	Shredder	burrower	1		1	2		
Baetidae	4	Collector	swimmer			41	3	7	10
Elmidae	4	Scraper	clinger		1				
Ephemerellidae	4	Collector	clinger		1				
Heptageniidae	4	Scraper	clinger	3	3				
Cambaridae	5	Shredder			1			1	1
Pyralidae	5	Shredder	climber		1				
Ancylidae	6	Scraper	clinger			1	9		2
Chironomidae (A)	6	Collector		3	31	72	6	88	5
Empididae	6	Predator	sprawler				2		
Hydropsychidae	6	Filterer	clinger	85	33	4	68	2	76
Hydroptilidae	6	Scraper	clinger		1				
Simuliidae	6	Filterer	clinger	7		14	1	3	
Planorbidae	7	Scraper							1
Asellidae	8	Collector	sprawler						1
Corbiculidae	8	Filterer	sprawler		6				
Lumbriculidae	8	Collector		3	10	4	6	1	3
Naididae	8	Collector	burrower		13	19	0	62	1
Physidae	8	Scraper				26	6		4
Sphaeriidae	8	Filterer	sprawler				1		
Tubificidae	10	Collector	burrower			4			
Lumbricidae		Collector	burrower						2
Oligochaeta (unknown)		Collector	burrower						1
		No. of Species		6	11	10	10	7	12
		Abundance		102	101	186	104	164	107
		Additional Benthic							
		Scraper/Filter-Collector Ratio		0.03	0.05	0.17	0.18	0.00	0.07
		%Filterer-Collector		96.1%	93.1%	84.9%	81.7%	99.4%	92.5%
		%Haptobenthos		93.1%	38.6%	10.2%	75.0%	3.0%	72.9%
		%Shredder		1.0%	2.0%	0.5%	1.9%	0.6%	0.9%

- Dominant 2 species in each sample.

Table 2-3. Taxa Inventory by Sample Date in Meadow Creek (MWC), Schenks Branch (SNK), and an Unnamed Tributary to Schenks Branch (XSN)

				Meadow Creek					Schenks Branch				Unnamed Tributary, Schenks Branch			
				2-MWC000.60					2-SNK000.88				2-XSN000.08			2-XSN000.18
Taxa	Tolerance Value	Functional Family Group	Habit	04/21/04	10/27/04	05/12/08	10/27/08	03/30/09	03/30/05	03/20/08	03/30/09	03/30/09	03/30/05	03/20/08	03/30/09	03/30/05
Isonychiidae	2	Filterer	swimmer				1									
Tipulidae	3	Shredder	burrower	4	14	32	3	2	1	2	1	2		2	3	
Baetidae	4	Collector	swimmer	12	2	12										
Elmidae	4	Scraper	clinger		1	4										
Cambaridae	5	Shredder									1					
Pyralidae	5	Shredder	climber										1			
Ancylidae	6	Scraper	clinger							1						
Chironomidae (A)	6	Collector		79	16	20	9	101	49	28	39	38	50	28	23	40
Hydropsychidae	6	Filterer	clinger		68	27	43	6	4	21	8	9		17	9	
Hydroptilidae	6	Scraper	clinger					1								
Simuliidae	6	Filterer	clinger	6		5	45									
Lumbriculidae	8	Collector			7	1	4	1	15		5		12	3	3	16
Naididae	8	Collector	burrower	37	1		1	7	108	44	45	53	62	66	67	60
Physidae	8	Scraper							3	1		2			1	41
Tricladida (unknown)	8	Collector							2							
Coenagrionidae	9	Predator	climber											1		
Tubificidae	10	Collector	burrower			1			1		3			1		
Oligochaeta (unknown)		Collector								1						
		No. of Species		5	7	8	7	6	8	7	7	5	4	7	6	4
		Abundance		138	109	102	106	118	183	98	102	104	125	118	106	157
		Additional Benthic														
		Scraper/Filter-Collector Ratio		0.00	0.04	0.12	0.00	0.01	0.02	0.03	0.00	0.02	0.00	0.00	0.01	0.35
		%Filterer-Collector		92.8%	23.9%	33.3%	13.2%	92.4%	95.6%	74.5%	90.2%	87.5%	99.2%	83.1%	87.7%	73.9%
		%Haptobenthos		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		%Shredder		2.9%	12.8%	31.4%	2.8%	1.7%	0.5%	2.0%	2.0%	1.9%	0.8%	1.7%	2.8%	0.0%

- Dominant 2 species in each sample.

DEQ, with assistance from USEPA Region 3, has recently upgraded its biomonitoring and biological assessment methods to those currently recommended in the mid-Atlantic region. As part of this effort, a study was performed to assist the agency in moving from a paired-network/reference site approach based on the RBP II to a regional reference condition approach, and has led to the development of the Virginia Stream Condition Index (VSCI) for Virginia's non-coastal areas (Tetra Tech, 2003). This multi-metric index is based on 8 biomonitoring metrics, with a scoring range of 0-100, that include some different metrics than those used previously in the RBP II, but are based on the same taxa inventory. A maximum score of 100 represents the best benthic community sites. The current proposed threshold criteria would define "non-impaired" sites as those with a VSCI of 60 or above, and "impaired" sites as those with a score below 60 (VADEQ, 2006). The VSCI scores for Moores Creek and

Meadow Creek are shown in Table 2-4 and for Meadow Creek and Schenks Branch in Table 2-6.

Table 2-4. Virginia Stream Condition Index (VSCI) Scores for Moores Creek (MSC) and Lodge Creek (XRC)

StationID	2-MSC000.60		2-XRC001.15			
Collection Date	10/26/06	03/20/08	04/29/02	10/16/02	04/21/04	09/30/09
VSCI Metric Values						
Richness	6	11	10	10	7	11
EPT Taxa	2	4	2	2	2	2
%Ephemeroptera	2.9	4.0	22.0	2.9	4.3	9.3
%PT - Hydropsychidae	0.0	1.0				
%Scrapers	2.9	5.0	14.5	14.4	0.0	6.5
%Chironomidae	2.9	30.7	38.7	5.8	53.7	4.7
%2Dominant	90.2	63.4	60.8	74.0	91.5	80.4
Modified Family Biotic Index	6.0	6.5	6.2	6.1	6.7	6.1
VSCI Metric Scores						
Richness Score	27.3	50.0	45.5	45.5	31.8	50.0
EPT Taxa Score	18.2	36.4	18.2	18.2	18.2	18.2
%Ephem Score	4.8	6.5	36.0	4.7	7.0	15.2
%PT-H Score	0.0	2.8	0.0	0.0	0.0	0.0
%Scrapers Score	5.7	9.6	28.1	28.0	0.0	12.7
%Chironomidae Score	97.1	69.3	61.3	94.2	46.3	95.3
%2Dom Score	14.2	52.9	56.7	37.5	12.3	28.4
%MFBI Score	59.3	52.1	56.5	56.8	48.9	58.0
VSCI	**28.3**	**34.9**	**37.8**	**35.6**	**20.6**	**34.7**

- Primary biological effects.

Table 2-5. Virginia Stream Condition Index (VSCI) Scores for Meadow Creek (MWC), Schenks Branch (SNK), and an Unnamed Tributary to Schenks Branch (XSN)

StationID	2-MWC000.60					2-SNK000.88				2-XSN000.08			2-XSN000.18
Collection Date	04/21/04	10/27/04	05/12/08	10/27/08	03/30/09	03/30/05	03/20/08	03/30/09	03/30/09	03/30/05	03/20/08	03/30/09	03/30/05
VSCI Metric Values													
Richness	5	7	8	7	6	8	7	7	5	4	7	6	4
EPT Taxa	1	2	2	2	2	1	1	1	1		1	1	
%Ephemeroptera	8.7	1.8	11.8	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%PT - Hydropsychidae	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%Scrapers	0.0	0.9	3.9	0.0	0.8	1.6	2.0	0.0	1.9	0.0	0.0	0.9	26.1
%Chironomidae	57.2	14.7	19.6	8.5	85.6	26.8	28.6	38.2	36.5	40.0	23.7	21.7	25.5
%2Dominant	84.1	77.1	57.8	83.0	91.5	85.8	73.5	82.4	87.5	89.6	79.7	84.9	64.3
Modified Family Biotic Index	6.3	5.7	4.8	6.0	6.1	7.4	6.9	7.1	7.0	7.2	7.2	7.3	7.5
VSCI Metric Scores													
Richness Score	22.7	31.8	36.4	31.8	27.3	36.4	31.8	31.8	22.7	18.2	31.8	27.3	18.2
EPT Taxa Score	9.1	18.2	18.2	18.2	18.2	9.1	9.1	9.1	9.1	0.0	9.1	9.1	0.0
%Ephem Score	14.2	3.0	19.2	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%PT-H Score	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%Scrapers Score	0.0	1.8	7.6	0.0	1.6	3.2	4.0	0.0	3.7	0.0	0.0	1.8	50.6
%Chironomidae Score	42.8	85.3	80.4	91.5	14.4	73.2	71.4	61.8	63.5	60.0	76.3	78.3	74.5
%2Dom Score	23.0	33.1	60.9	24.5	12.2	20.5	38.3	25.5	18.1	15.0	29.4	21.8	51.5
%MFBI Score	54.8	63.1	76.4	59.2	57.6	38.2	46.1	43.3	44.1	41.5	41.5	40.4	36.9
VSCI	**20.8**	**29.5**	**37.4**	**28.4**	**16.7**	**22.6**	**25.1**	**21.4**	**20.1**	**16.8**	**23.5**	**22.3**	**29.0**

- Primary biological effects.

The VSCI scores for all six monitoring sites clearly fall within the “impaired” category, as shown in Figure 2-4.

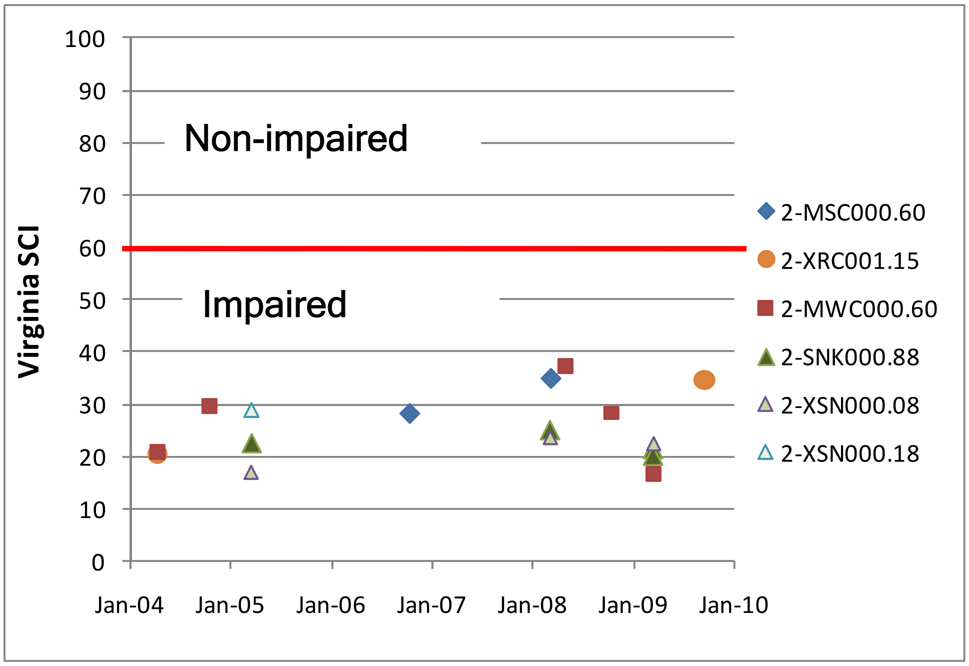

Figure 2-4. VSCI Scores for Moores Creek (MSC), Lodge Creek (XRC), Meadow Creek (MWC), Schenks Branch (SNK), and Schenks Branch Unnamed Tributary (XSN)

A qualitative analysis of various habitat parameters was conducted in conjunction with each biological sampling event. Habitat data collected as part of the biological monitoring were obtained from DEQ through the EDAS database. Each of the 10 parameters included in the habitat assessment was rated on a scale of 0-20, with a maximum score of 20 indicating the most desirable condition, and a score of 0 indicating the poorest habitat conditions. The best possible overall score for a single evaluation is 200. Many of the “poor” to “marginal” habitat scores shown in these two tables relate fairly closely with the sediment stressor. The habitat assessment data are shown for Moores Creek and Lodge Creek in Table 2-6, and for Meadow Creek and Schenks Branch in Table 2-9.

Table 2-6. Habitat Evaluation Scores for Moores Creek (MSC) and Lodge Creek (XRC)

StationID	2-MSC000.60		2-XRC001.15			
Collection Date	10/26/06	03/20/08	04/29/02	10/16/02	04/21/04	09/30/09
Channel Alteration	13	18	10	9	17	13
Bank Stability	8	17	14	14	11	6
Vegetative Protection	18	17	9	12	20	14
Embeddedness	11	14	13	13	13	13
Channel Flow Status	18	18	10	20	9	8
Frequency of riffles (or bends)	11	17	18	17	19	18
Riparian Vegetative Zone Width	4	12	2	4	2	4
Sediment Deposition	16	14	11	13	18	18
Epifaunal Substrate / Available Cover	13	16	19	11	18	16
Velocity / Depth Regime	16	17	9	13	8	12
10-metric Total Habitat Score	**128**	**160**	**115**	**126**	**135**	**122**
Average Station Score	**144**		**124.5**			

- Marginal or Poor habitat metric rating.

Table 2-7. Habitat Evaluation Scores for Meadow Creek (MWC), Schenks Branch (SNK), and the Unnamed Tributary to Schenks Branch (XSN)

StationID	2-MWC000.60					2-SNK000.88			2-XSN000.08			2-XSN000.18
Collection Date	04/21/04	10/27/04	05/12/08	10/27/08	03/30/09	03/30/05	03/20/08	03/30/09	03/30/05	03/20/08	03/30/09	03/30/05
Channel Alteration	19	18	18	18	19	6	10	2	6	12	7	2
Bank Stability	8	2	9	4	6	14	17	12	6	14	10	5
Vegetative Protection	20	18	16	18	18	17	11	12	18	12	14	14
Embeddedness	8	5	12	5	12	2	13	11	5	12	8	6
Channel Flow Status	8	15	18	10	8	16	17	15	15	16	10	15
Frequency of riffles (or bends)	18	18	17	17	17	16	18	18	16	18	16	17
Riparian Vegetative Zone Width	20	18	18	18	18	3	9	6	4	7	7	2
Sediment Deposition	6	3	10	10	9	7	13	14	4	11	15	13
Epifaunal Substrate / Available Cover	13	15	16	16	17	11	16	18	10	15	15	14
Velocity / Depth Regime	13	16	17	13	16	13	10	13	13	11	13	13
10-metric Total Habitat Score	**133**	**128**	**151**	**129**	**140**	**105**	**134**	**121**	**97**	**128**	**115**	**101**
Average Station Score	**136.2**					**120**			**113.3**			**101**

- Marginal or Poor habitat metric rating.

2.7. Water Quality Data

2.7.1. DEQ Ambient Monitoring Data

DEQ monitored chemical and bacterial water quality at six different stations with various periods of record between 1968 and the present, as shown in Table 2-8. The Moores Creek (MSC) impaired segment was monitored at the 2-MSC000.60 biological station in 2006 and 2008, with ambient sample collection at the same station from 1991 through 2007. Additional ambient sampling occurred downstream at station 2-MSC000.11 from 1968-79, and again in 2003 and 2010; and upstream at station 2-MSC004.43 between 2005 and 2006. No ambient data are available for 2-XRC001.15, except for physical parameters collected on the date of biological sampling. The Meadow Creek (MWC) impaired segment has been monitored at the 2-MWC000.60 biological station since 2004, with ambient sample collection at the same station since 1991. The Schenks Branch (SNK) impaired segment was monitored at the 2-SNK000.88 biological station between 2005 and 2009, and at two locations on an unnamed tributary. Ambient samples have been collected at the biological station and at one of the unnamed tributary (XSN) sites (2-XSN000.08) since 2008.

Table 2-8.Summary of Ambient Monitoring Data through October 2010

Station	Stream Name	Period	No. of Samples
2-MSC000.11	Moores Creek	1968 - 1979	87
2-MSC000.60		1991 - 2007	55
2-MSC004.43		2005 - 2006	9
2-MWC000.60	Meadow Creek	1991 - 2010	59
2-SNK000.88	Schenks Branch	2008 - 2010	2
2-XSN000.08	Schenks Branch UT	2008 - 2010	2

Chemical parameters included various forms of nitrogen and phosphorus – ammonia, total Kjeldahl nitrogen (TKN), nitrite plus nitrate-N, total N, and total P; dissolved oxygen (DO); various forms of solids – total solids, volatile solids, and suspended solids; chemical oxygen demand (COD); alkalinity; chlorides; sulfates; and total dissolved solids (TDS). Field physical parameters included temperature, pH, DO, and conductivity.

All stream segments within these watersheds are Class III Non-tidal Waters Coastal and Piedmont Zones (SWCB, 2010). Where applicable, minimum and/or maximum water quality standards (WQS) are indicated on the following plots, as are minimum detection limits (MDL) of various laboratory analysis techniques. Plots of monthly ambient water quality monitoring sample data are shown in Figures 2-5 through 2-27 for the six ambient monitoring stations in this watershed.

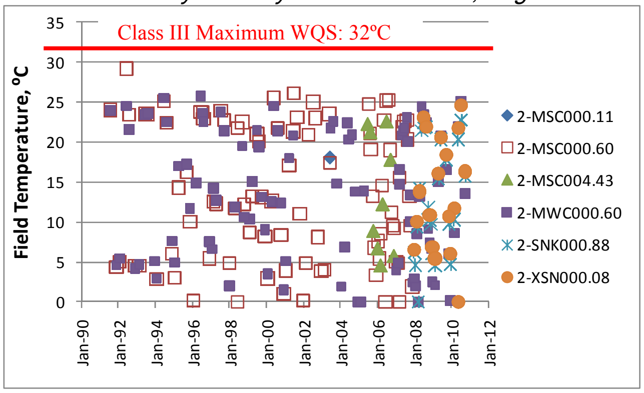

Figure 2-5. Field Temperature

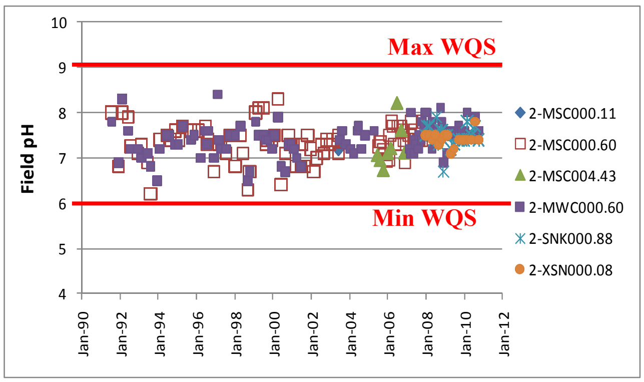

Figure 2-6. Field pH

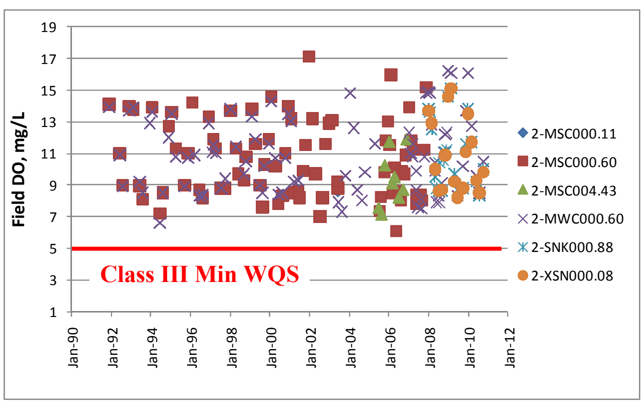

Figure 2-7. Field DO

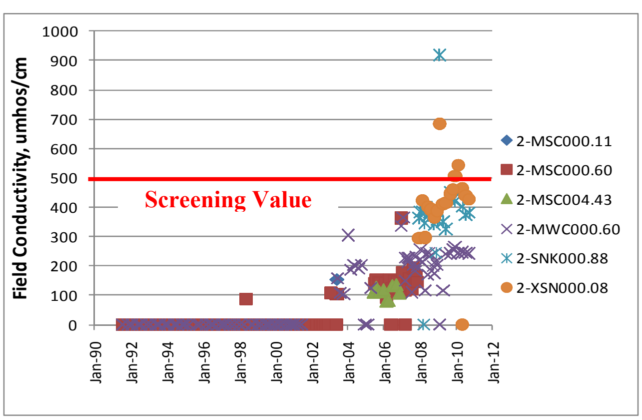

Figure 2-8. Field Conductivity

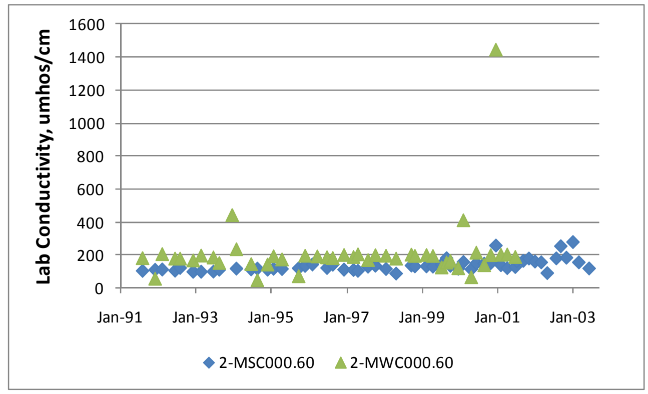

Figure 2-9. Lab Conductivity

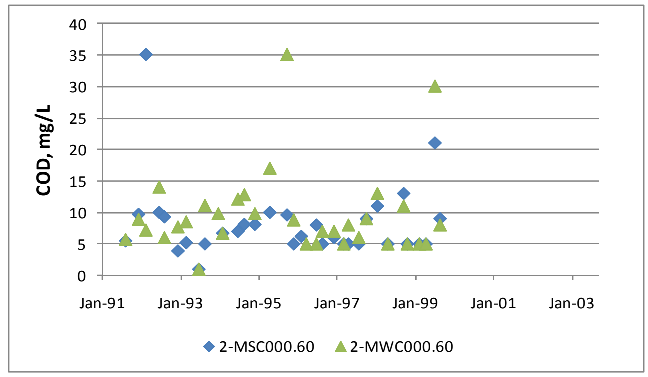

Figure 2-10. Lab COD

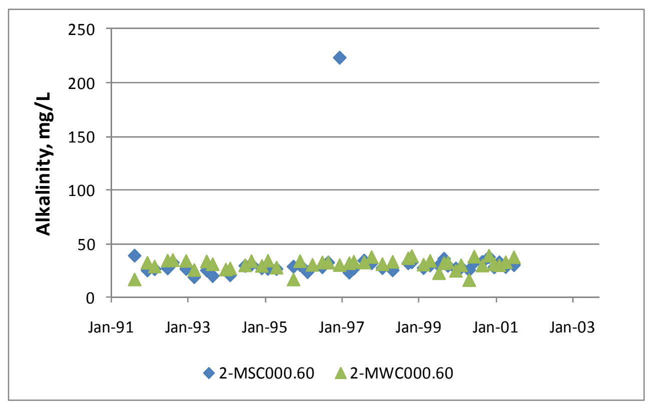

Figure 2-11. Alkalinity

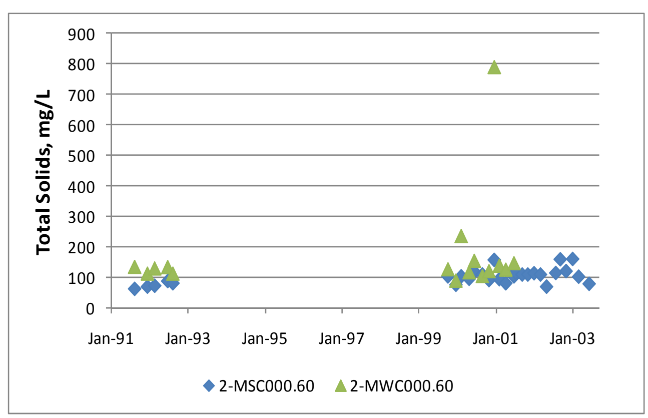

Figure 2-12. Total Solids

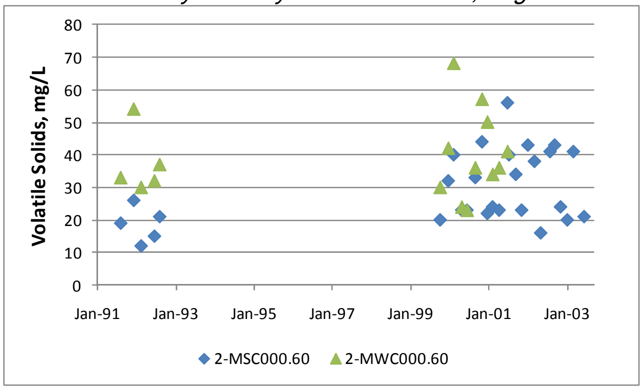

Figure 2-13. Volatile Solids

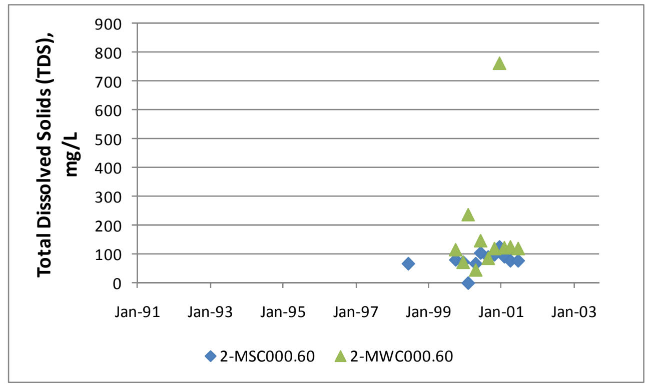

Figure 2-17. Total Dissolved Solids (TDS)

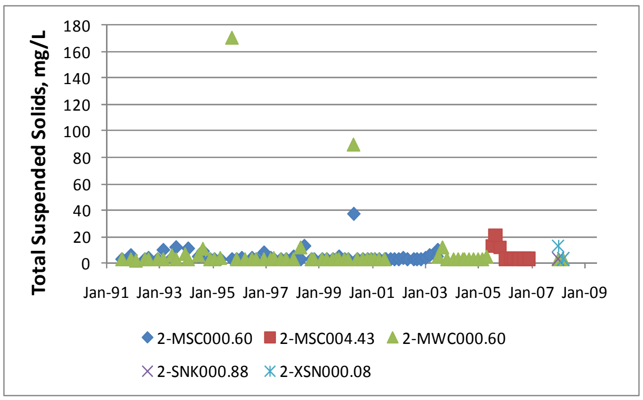

Figure 2-14. Total Suspended Solids (TSS)

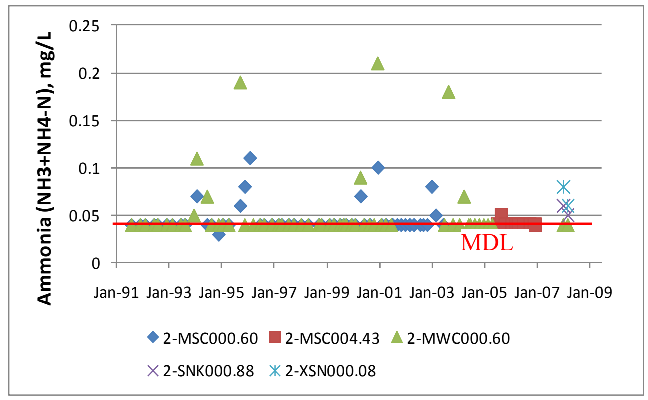

Figure 2-18. Ammonia

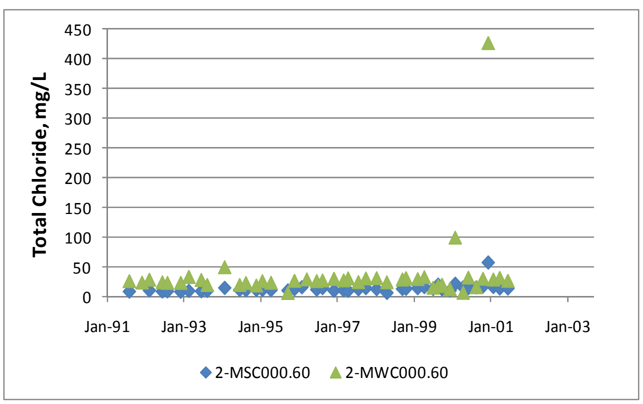

Figure 2-15. Total Chloride

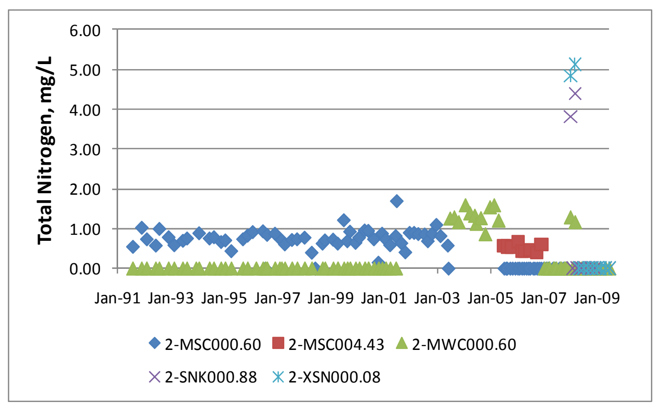

Figure 2-19. Total Nitrogen

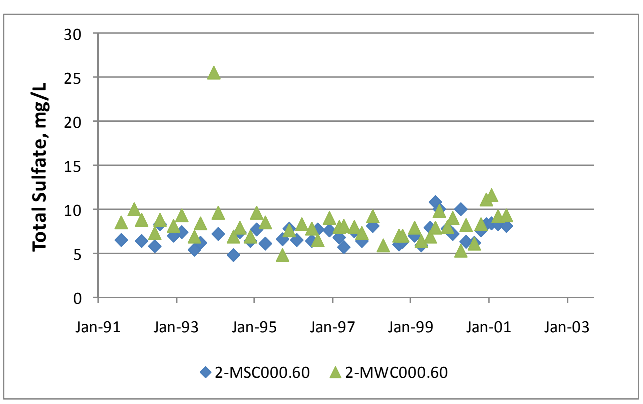

Figure 2-16. Total Sulfate

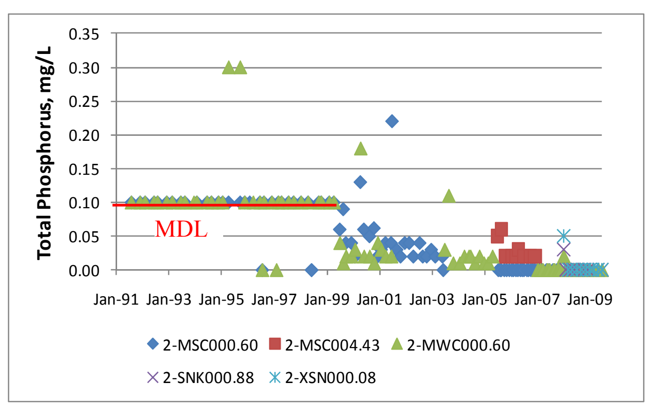

Figure 2-20. Total Phosphorus

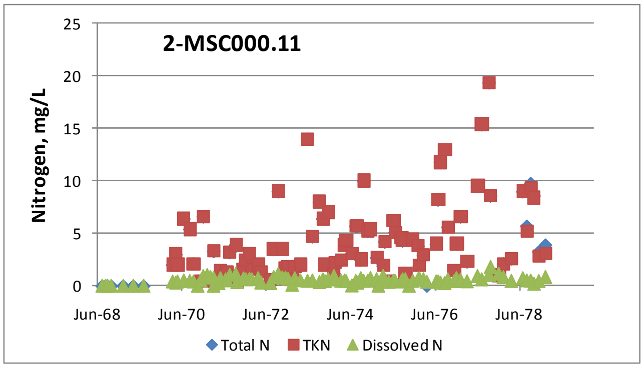

Figure 2-21. Nitrogen - 2-MSC000.11

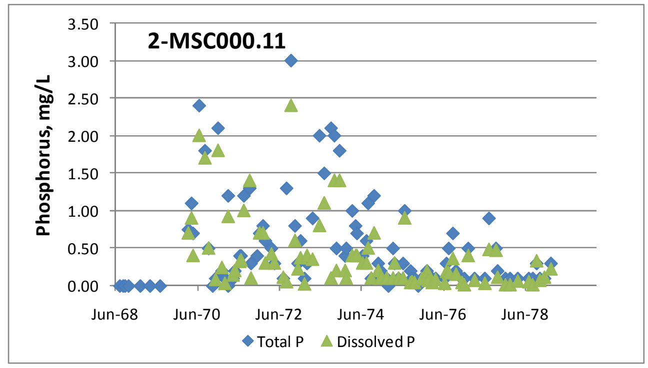

Figure 2-25. Phosphorus - 2-MSC000.11

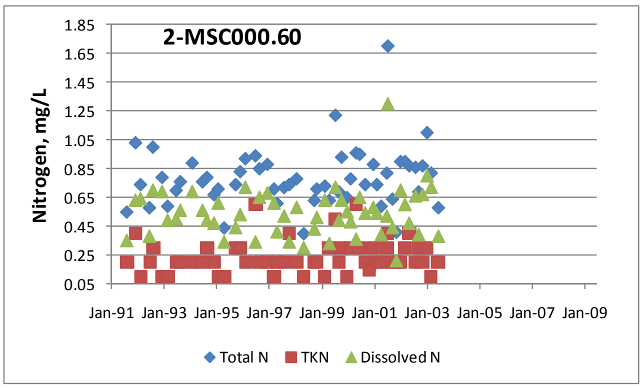

Figure 2-22. Nitrogen - 2-MSC000.60

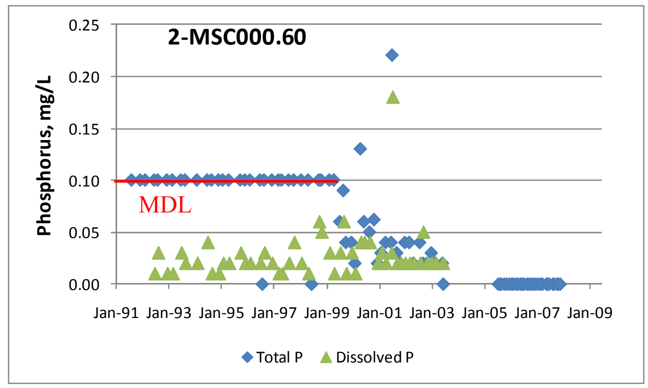

Figure 2-26. Phosphorus - 2-MSC000.60

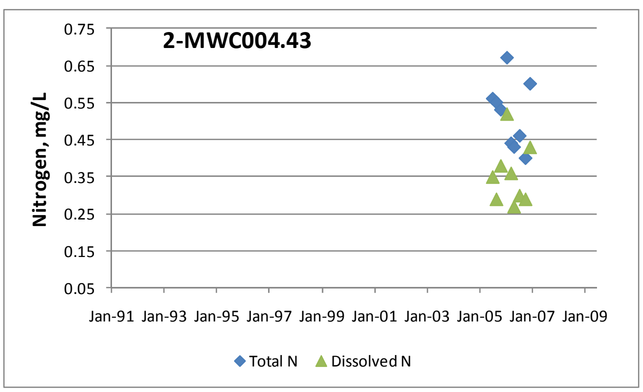

Figure 2-23. Nitrogen - 2-MSC004.43

Intentionally left blank to allow side-by-side display of corresponding N and P samples from each monitoring site.

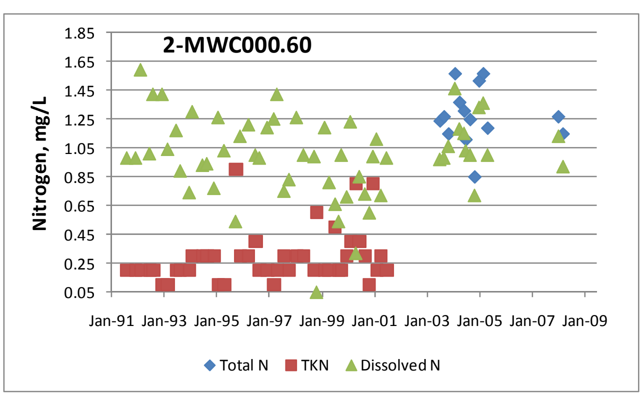

Figure 2-24. Nitrogen - 2-MWC000.60

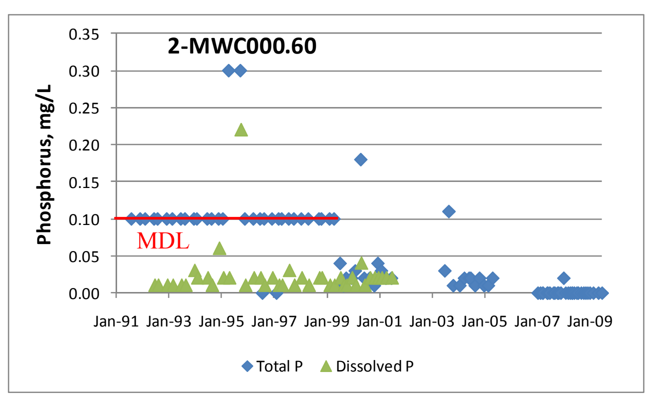

Figure 2-27. Phosphorus - 2-MWC000.60

2.7.2. DEQ Metals Monitoring Data

Stream sediment and water column samples have been collected and analyzed for a standard suite of metals and toxic substances periodically in three of the four impaired watersheds. None of the tested substances in channel bottom sediments exceeded any of the known probable effect concentrations (PECs; MacDonald et al., 2000), or alone any of the minimum detectable threshold effects concentrations (TECs) shown in red in Table 2-9; and none of the tested substances in the water column exceeded known freshwater aquatic life, public water supply (PWS), or human health criteria (SWCB, 2010) shown in red in Table 2-10. Values shown in purple were either at or below their respective minimum detection limits. Multiple numbers divided by a "/" indicate varying minimum detection limits between samples. In both tables, the blue numbers under the column heading "No." indicate the number of samples that were taken during the indicated period and the "Value" column represents the average concentration from all samples.

Table 2-9. DEQ Channel Bottom Sediment Monitoring for Metals

Parameter Name	Parameter Code	2-MSC000.60		2-MWC000.60		2-SNK000.88		Minimum	Consensus-Based	
		1991 - 2003		1991 - 1997		2008		Detection	TEC	PEC
		No.	Value	No.	Value	No.	Value	Limit	(mg/kg)	(mg/kg)
AL MUD DRY WGT MG/KG-AL	1108	1	10900	2	4065	1	5110	#N/A		
ALDRIN SEDUG/KG DRY WGT	39333	2	30/100	2	30/100	0		30/100		
ANTIMONYSEDMG/KG DRY WGT	1098	1	12	2	5	1	5	5		
ARSENIC SEDMG/KG DRY WGT	1003	2	5	3	5	1	5	5	9.79	33
BERYLIUMSEDMG/KG DRY WGT	1013	2	5	3	5	1	5	5		
CD MUD DRY WGT MG/KG-CD	1028	2	5	3	5	1	1	5		
CDANEDRYTECH and METMUDUG/KG	39351	1	500	2	40/500	0		40/500		
CHROMIUMSEDMG/KG DRY WGT	1029	2	14.5	3	14.33	1	15.5	#N/A		
COPPER SEDMG/KG DRY WGT	1043	2	18.5	3	9	1	17.4	#N/A	31.6	149
DDD MUD UG/KG	39363	2	10/100	2	10/100	0		10/100		
DDE MUD UG/KG	39368	2	10/100	2	10/100	0		10/100		
DDT MUD UG/KG	39373	2	30/100	2	30/100	0		30/100		
DICOFOL SED,DRYWT,UG/KG	79799	2	70/100	2	70/100	0		70/100		
DIELDRINSEDUG/KG DRY WGT	39383	2	10/100	2	10/100	0		10/100		
ENDRIN SEDUG/KG DRY WGT	39393	2	30/100	2	30/100	0		30/100		
FE MUD DRY WGT MG/KG-FE	1170	1	24800	2	10675	1	17400	#N/A		
HEPTCHLRSEDUG/KG DRY WGT	39413	2	10/100	2	10/100	0		10/100		
HPCLEPOX SED,DRYWT,UG/KG	75045	2	30/100	2	10/100	0		10/30/100		
LEAD SEDMG/KG DRY WGT	1052	2	14	3	14	1	28.7	#N/A	35.8	128
MERCURY SEDMG/KG DRY WGT	71921	2	0.3	3	0.3	1	0.1	0.3	0.16	1.06
MN MUD DRY WGT MG/KG-MN	1053	1	315	2	124.5	1	232	#N/A		
NICKEL SEDMG/KG DRY WGT	1068	2	8.5	3	5.67	1	7.4	5	22.7	48.6
PCBS TOTSED DRYWT UG/KG	39526	2	30/500	2	30/500	0		30/500		
PCP SEDUG/KG DRY WGT	39061	2	50/70	2	50/70	0		50/70		
SELENIUMSEDMG/KG DRY WGT	1148	2	1	3	1	1	1	1		
SILVER SEDMG/KG DRY WGT	1078	2	5	3	5	1	1	5		
THALLIUMSEDMG/KG DRY WGT	34480	1	5	2	5	1	5	5		
THALLIUMSEDMG/KG DRY WGT	34480	1	5	2	5	1	5			
TOXAPHENSEDUG/KG DRY WGT	39403	2	140/1000	2	50/1000	0		140/50/1000		
ZINC SEDMG/KG DRY WGT	1093	2	52	3	36.33	1	61.8	#N/A	121	459

Table 2-10. DEQ Water Column Monitoring for Metals

Parameter Name	Parameter Code	2-MSC000.11 1970 - 2003 No.	2-MSC000.11 1970 - 2003 Value	2-MSC000.60 1991 - 2003 No.	2-MSC000.60 1991 - 2003 Value	2-MWC000.60 1991 - 1997 No.	2-MWC000.60 1991 - 1997 Value	Minimum Detection Limit	Freshwater Chronic (ug/L)	Freshwater Acute (ug/L)	Human PWS (ug/L)	Human Other (ug/L)
ALUMINUM AL,DISS UG/L	1106	1	6.74	2	4.835	0		#N/A			14	4,300
ANTIMONYSB,DISS UG/L	1095	1	0.16	2	0.1	0		0.1			5.6	640
ARSENIC AS,DISS UG/L	1000	1	0.24	2	0.14	0		#N/A	150	340	10	
ARSENIC AS,TOT UG/L	1002	11	4.09	0		0		2				
BARIUM BA,DISS UG/L	1005	1	18.00	1	24	0		#N/A			2,000	
BERYLIUMBE,DISS UG/L	1010	1	0.1	1	0.1	0		0.1				
CADMIUM CD,DISS UG/L	1025	1	0.1	2	0.1	0		0.1	1.1	3.9	5	
CADMIUM CD,TOT UG/L	1027	14	10	0		0		10				
CAL HARD CA MG MG/L	46570	1	37.00	1	33	0		#N/A				
CALCIUM CA,DISS MG/L	915	1	10.20	2	7.5	0		#N/A				
CHROMIUMCR,DISS UG/L	1030	1	0.1	2	0.1	0		0.1	11	16	50	
CHROMIUMCR,TOT UG/L	1034	23	13.48	0		0		10				
COPPER CU,DISS UG/L	1040	1	1.53	2	0.93	0		#N/A	9	13	1,300	
COPPER CU,TOT UG/L	1042	22	9.55	0		0		10				
FLUORIDE F,TOTAL MG/L	951	0		6	0.20	7	0.19	0.1/0.3/0.5				
IRON FE,DISS UG/L	1046	1	78.00	2	50/100	0		50/100			300	
IRON FE,TOT UG/L	1045	4	564.93	0		0		#N/A				
LEAD PB,DISS UG/L	1049	1	0.1	2	0.1	0		0.1	14	120	15	
LEAD PB,TOT UG/L	1051	22	11.95	0		0		0				
MANGNESE MN UG/L	1055	3	89.96	0		0		#N/A				
MANGNESEMN,DISS UG/L	1056	1	45.00	2	37.5	0		#N/A			50	
MERCURY HG,DISS UG/L	71890	0		1	0.2	0		0.2	0.77	1.4		
MERCURY HG,TOTAL UG/L	71900	22	0.55	0		0		0.3/0.5				
MERCURY-TL,FILTERED WATER	50091	1	1.86	1	1.5	0		1.5				
MGNSIUM MG,DISS MG/L	925	1	2.80	2	2.65	0		#N/A				
NICKEL NI,DISS UG/L*	1065	10	0.45	2	0.27	0		#N/A	20	180	610	4600
SELENIUMSE,DISS UG/L	1145	1	0.5	2	0.5	0		0.5	5	20	170	4200
SILICA DISOLVED MG/L	955	0		6	14.18	6	14.27	#N/A				
SILVER AG,DISS UG/L	1075	1	0.1	2	0.1	0		0.1	3.4			
THALLIUMTL,DISS UG/L	1057	1	0.2	2	0.2	0		0.2			0.24	0.47
ZINC ZN,DISS UG/L	1090	1	6.81	2	1	0		1	120	120	7,400	26,000
ZINC ZN,TOT UG/L	1092	23	22.60	0		0		10				

* Nine of the ten samples were below the minimum detection limit.

2.7.3. DEQ Polycyclic Aromatic Hydrocarbon (PAH) Monitoring Data

A series of sediment samples were taken and analyzed for toxic organic compounds beginning in March 2009 at various sites along the Rivanna River, Moores Creek, Meadow Creek, Schenks Branch, and at two sites along an unnamed tributary to Schenks Branch.

Many samples at the Schenks Branch sites exceeded the probable effects concentration (PEC) for a variety of PAH congeners, as shown in Table 2-11. Values in blue-shaded cells were below the threshold effect concentration (TEC) and values in light red-shaded cells were above the PEC for the given compound.

The literature describes several indices to determine both the dominant PAH source type and the relative potential for toxicity from the cumulative concentrations of various congeners, as shown in Table 2-12. While the two different tools used for this study do give slightly different results, the major PAH sources appear to be fairly consistently pyrogenic in nature; while the potential for toxic effects varies greatly between the two tools.

In Table 2-12, PH/AN is the ratio of Phenanthrene to Anthracene; FL/PY is the ratio of Fluoranthene to Pyrene; and Meth/PH is the ratio of 3 different methylphenthrene compounds to phenanthrene. All three ratios are between parent PAHs and their weathered products and can be used to differentiate between petrogenic and pyrogenic sources of PAHs.

Table 2-11. Summary of Major PAH Congener Values vs Consensus-Based TECs and PECs in DEQ Monitoring (March 2009 – September 2010)

All Measurements are in ug/kg

Stream Name	Sample Site	Sample Date	Naphthalene	Acenaphthalene	Acenaphthene	Flourene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benzo[a]anthracene	Chrysene	Benzo[b]fluoranthene	Benzo[k]fluoranthene	Benzo[a]pyrene	Indeno[1,2,3-cd]pyrene	Dibenz[a,h]anthracene	Benzo[g,h,i]perylene
Meadow Creek	2-MWC000.04	01/19/10	52	167	7.9	13.4	381	108	1493	1252	986	920	1548	418	1453	1743	1529	1100
		06/29/10	17.6	26.6	30.5	27	740	69.8	1460	1130	615	590	856	308	493	457	12.6	304
	2-MWC000.60	03/03/09	23.6	43.1	6.3	12.1	173	33.1	600	574	446	397	456	171	339	207		148
	2-MWC001.16	01/19/10	4.9	10	<12.9	2.2	57	8.6	261	219	113	122	182	69	129	106	25	83
		06/29/10	11.9	28.8	12.5	12.5	123	28.8	505	503	349	288	396	141	279	222	12.5	157
	2-MWC001.28	01/19/10	<12.9	<12.9	4	3.9	57	6.4	153	108	53	68	113	44	62	76	20	65
		06/29/10	11.6	14.5	34.1	24.8	248	35.8	491	344	215	264	350	113	160	177	14.5	118
Moores Creek	2-MSC000.11	09/13/10	12.8	5.4	9.77	12.8	238	39.1	648	485	301	368	406	152	227	196	53.3	157
Rivanna River	2BRVN039.91	09/13/10	36.4	30.1	15.8	22.2	421	47.5	1530	1220	664	1120	1480	465	722	842	163	657
Schenks Branch	2BSNK001.20	09/13/10	7.6	5.5	23.7	35.8	1140	97.4	1620	1140	688	770	812	272	495	463	89.8	343
	2-SNK000.02	01/19/10	14	37	8.6	15	280	43	959	784	433	451	721	253	525	436	98	359
		06/29/10	34.5	38	72	56.4	739	139	1870	1490	865	883	1140	377	633	676	14.4	459
	2-SNK000.88	03/03/09	25.2	52.4	34.7	52.4	777	114	1944	1808	810	850	897	323	576	442		318
	2-SNK001.02	01/19/10	12.7	43	4.4	13	376	42	767	676	255	282	460	197	341	327	189	297
		06/29/10	12.6	12.6	49.8	58.3	748	90.7	1170	771	449	433	455	159	234	300	12.6	201
Schenks Dry Channel	PC7002	01/19/10	28	52	19	18	330	54	1292	1059	598	629	1208	429	839	739	169	597
		06/29/10	67	82.7	35.6	46.4	802	136	2520	2240	1230	1300	2240	539	917	1350	17.8	968
Schenks X-Trib	2-XSN000.04	01/19/10	73	176	137	148	1826	344	3462	2725	689	1319	2564	782	2100	2526	471	1991
		06/29/10	22.3	29	30.5	40.2	842	117	2440	1930	1020	1260	1460	359	614	869	12.1	584
	2-XSN000.19	01/19/10	111	93	187	239	3424	522	6281	4311	1981	2982	4145	1561	3075	3285	1806	2565
		06/29/10	157	85.6	152	183	2750	398	7380	5350	2780	4060	5100	1100	2400	2190	606	1480
X-trib Stormwater	PC7022	01/19/10	22	58	10	10	146	44	761	904	523	402	1140	418	692	548	151	438
		06/29/10	21.4	35.2	11.5	13.8	137	41.8	590	758	623	477	802	286	344	416	13.8	261
Threshold Effect Concentration (TEC)			176			77.4	204	57.2	423	195	108	166			150		33	
Probable Effect Concentration (PEC)			561			536	1170	845	2230	1520	1050	1290			1450			

Table 2-12. Indices for Determining the Type of Source and Potential for Toxicity

Stream Name	Sample Site	Sample Date	PH/AN Ratio	FL/PY Ratio	Meth/PH Ratio	Mean-PEC Quotient
Meadow Creek	2-MWC000.04	01/19/10	3.53	1.19	--	0.65
		06/29/10	10.60	1.29	0.22	0.52
	2-MWC000.60	03/03/09	5.23	1.05	--	0.26
	2-MWC001.16	01/19/10	6.63	1.19	--	0.09
		06/29/10	4.27	1.00	0.65	0.21
	2-MWC001.28	01/19/10	8.91	1.42	--	0.05
		06/29/10	6.93	1.43	0.24	0.18
Moores Creek	2-MSC000.11	09/13/10	6.09	1.34	0.34	0.23
Rivanna River	2BRVN039.91	09/13/10	8.86	1.25	0.32	0.57
Schenks Branch	2BSNK001.20	09/13/10	11.70	1.42	0.16	0.60
	2-SNK000.02	01/19/10	6.51	1.22	--	0.35
		06/29/10	5.32	1.26	0.23	0.68
	2-SNK000.88	03/03/09	6.82	1.08	--	0.70
	2-SNK001.02	01/19/10	8.95	1.13	--	0.27
		06/29/10	8.25	1.52	0.21	0.41
Schenks Dry Channel	PC7002	01/19/10	6.11	1.22	--	0.48
		06/29/10	5.90	1.13	0.30	0.92
Schenks X-Trib	2-XSN000.04	01/19/10	5.31	1.27	--	1.27
		06/29/10	7.20	1.26	0.25	0.83
	2-XSN000.19	01/19/10	6.56	1.46	--	2.31
		06/29/10	6.91	1.38	0.21	2.57
X-trib Stormwater	PC7022	01/19/10	3.32	0.84	--	0.34
		06/29/10	3.28	0.78	0.56	0.29

Green = petrogenic sources (Neff et al., 2005)
Gray = pyrogenic sources (Neff et al., 2005)
Values > 0.5 indicate potential toxicity (McDonald et al., 2000)

2.7.4. DEQ – Other Relevant Monitoring or Reports

<u>Chlordane-related sampling</u>: An error in reported units on an earlier sample taken in March 3, 2009 resulted in additional samples being tested for chlordane and related parameters at various locations around the Meadow Creek and Schenks Branch watersheds on January 19, 2010 and June 29, 2010. Table 2-13 contains the corrected values for the original date together with the later data for Meadow Creek; Table 2-14 lists the data for Schenks Branch. The parameter values resulting from analysis of these samples showed that one later sample (highlighted in yellow in the table) had elevated chlordane concentrations greater than its Probable Effects Concentration in an unnamed tributary of Schenks Branch.

Table 2-13. Chlordane-Related Samples in Meadow Creek

Parameter Code	Parameter Name	2-MWC000.04		MWC0.60	2-MWC001.16		2-MWC001.28		Consensus-Based	
		01/19/10	06/29/10	03/03/09	01/19/10	06/29/10	01/19/10	06/29/10	TEC (ug/kg)	PEC (ug/kg)
00687	CARBON, ORGANIC, IN BED MATERIAL (GM/KG AS C)	15.61	3.03		3.54	2.6	5.04	9.94		
39413	HEPTACHLOR IN BOT. DEP. (UG/KILOGRAM DRY SOLIDS)	0	2.25		0	2.5	0	2.9		
50784	ALPHA-CHLORDANE SEDIMENT,DRY WT,BOT. DEP UG/KG	0	1.755	0.48	2.6	1.5	2.6	1.73	3.24	17.6
50966	GAMMA-CHLORDANE, DRY WEIGHT, SEDIMENT UG/KG	0	1.755	2.6	2.6	2.5	2.6	2.9	3.24	17.6
75042	HEXACHLOROBENZENE SEDIMENT,DRY,WT,UG/KG	0	2.25		0	2.5	0	2.9		
75045	HEPTACHLOR EPOXIDE SEDIMENT,DRY,WT,UG/KG	0	2.25		2.6	2.5	2.6	2.9	2.47	16.0
82007	PERCENT SAND IN SEDIMENT ON A DRY WEIGHT BASIS	79.48	95.62		94.23	93.3	94.48	78.2		
82008	SEDIMENT PRCTL.SIZE CLASS .0039-.0625 SILT DRY WT	13.34	2.5		2.91	3.71	2.83	13.43		
82009	SEDIMENT PRCTL.SIZE CLASS <.0039 CLAY DRY WT	7.17	1.87		2.87	2.98	2.69	8.37		

Table 2-14. Chlordane-Related Samples in Schenks Branch

Parameter Code	Parameter Name	2-SNK000.02		SNK0.88	2-SNK001.02		2-XSN000.04		2-XSN000.19		PC7002		PC7022		Consensus-Based	
		01/19/10	06/29/10	03/03/09	01/19/10	06/29/10	01/19/10	06/29/10	01/19/10	06/30/10	01/19/10	06/29/10	01/19/10	06/29/10	TEC (ug/kg)	PEC (ug/kg)
00687	CARBON, ORGANIC, IN BED MATERIAL (GM/KG AS C)	9.51	17.6		5.06	11.2	26.27	14.3	25.99	60.6	69.77	46.6	41.34	29.2		
39413	HEPTACHLOR IN BOT. DEP. (UG/KILOGRAM DRY SOLIDS)	0	2.9		0	2.5	0	2.4	0	3.3	0	3.6	0	2.8		
50784	ALPHA-CHLORDANE SEDIMENT,DRY WT,BOT. DEP UG/KG	2.6	5.18	4.1	0	12	0	7.78	0	27	3.8	10.7	3	2.21	3.24	17.6
50966	GAMMA-CHLORDANE, DRY WEIGHT, SEDIMENT UG/KG	2.6	5.18	5.2	0	13.6	0	8.27	0	30.2	3.8	10.7	3.3	2.8	3.24	17.6
75042	HEXACHLOROBENZENE SEDIMENT,DRY,WT,UG/KG	0	2.9		0	2.5	0	2.4	0	3.3	0	3.6	0	2.8		
75045	HEPTACHLOR EPOXIDE SEDIMENT,DRY,WT,UG/KG	2.6	2.9		0	2.5	0	2.4	0	3.3	3.8	3.6	3	2.8	2.47	16.0
82007	PERCENT SAND IN SEDIMENT ON A DRY WEIGHT BASIS	86.94	78.76		92.09	83.43	82.97	89.69	93.12	57.65	20.8	23	55.58	73.16		
82008	SEDIMENT PRCTL.SIZE CLASS .0039-.0625 SILT DRY WT	6.69	14.61		4.28	9.54	10.31	6.96	3.66	25.03	54.21	50.04	30.98	14.97		
82009	SEDIMENT PRCTL.SIZE CLASS <.0039 CLAY DRY WT	6.36	6.64		3.64	7.03	6.72	3.35	3.22	17.32	24.99	26.96	13.44	11.87		

Diurnal dissolved oxygen (DO) tests: No violations were observed of either the minimum dissolved oxygen standard of 4.0 mg/L, or the daily average standard of 5.0 mg/L for Class III waters, as shown in Figure 2-28.

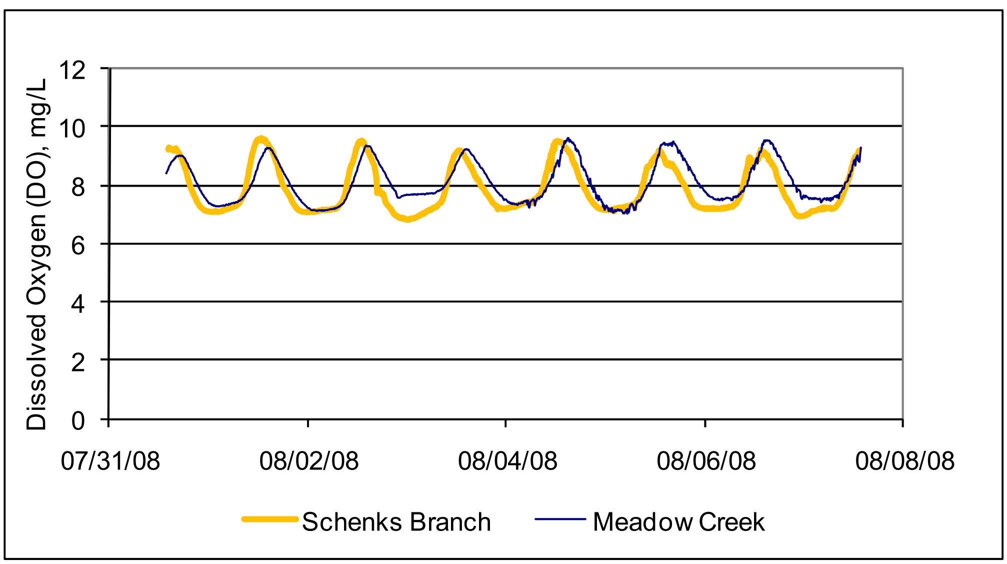

Figure 2-28. 4-Day Diurnal DO Results on Meadow Creek and Schenks Branch

Relative Bed Stability (RBS) Analysis: The RBS analysis showed that both Meadow Creek and Schenks Branch had a high percentage of fine sediment in the streams that directly contribute to embeddedness – the filling of the interstitial spaces in the channel bottom, as shown in Table 2-15. This percentage is very similar to that found in the Rivanna River (RVN), where sediment was determined to be one of the most probable stressors for its benthic impairment.

Table 2-15. RBS Analysis Results for Meadow Creek and Schenks Branch

Station	Sample Date	Mean Substrate Size (mm)	LRBS	Mean Embeddedness (channel + margin) (%)	% fines
2-SNK000.88	08/11/08	1.626	-0.029	42.6	22.9
2-MWC000.60	08/11/08	1.200	-0.248	54.2	22.9
2-RVN033.65	07/12/07				23.8

Pollutant Response Program (PReP) Reports: The majority of reported incidences in these watersheds related to sewage overflows during storm events. Two incidents were of note, however, as shown in Table 2-16, since they were both petroleum-related, and the high PAH samples in this watershed were collected 9 months later in March 2009.

Table 2-16. Selected PReP Incidences

Incident Date	Site Name	Quantity Released	Unit	Material Released	Receiving Water	Incident Summary
06/25/08	Near English Inn	-1	Gallons	Unknown Petroleum	Meadow Creek	Caller reported a petroleum sheen and odor on Meadow Creek.
06/23/08	Tar Truck Fuel Release	15	Gallons	diesel fuel	Schenks Branch	A tar truck had a ruptured diesel fuel line that released 15 gallons of fuel onto roadway and into storm drain that leads to a stream called schenks branch.

Reported petroleum releases: The distribution of petroleum releases in the watersheds is illustrated in Figure 2-29 and summarized in Table 2-17. Those releases reported as “2006” in the figure and “pre2007” in the summary are comprised of an unknown number of years of data that were first entered in the database in 2006.

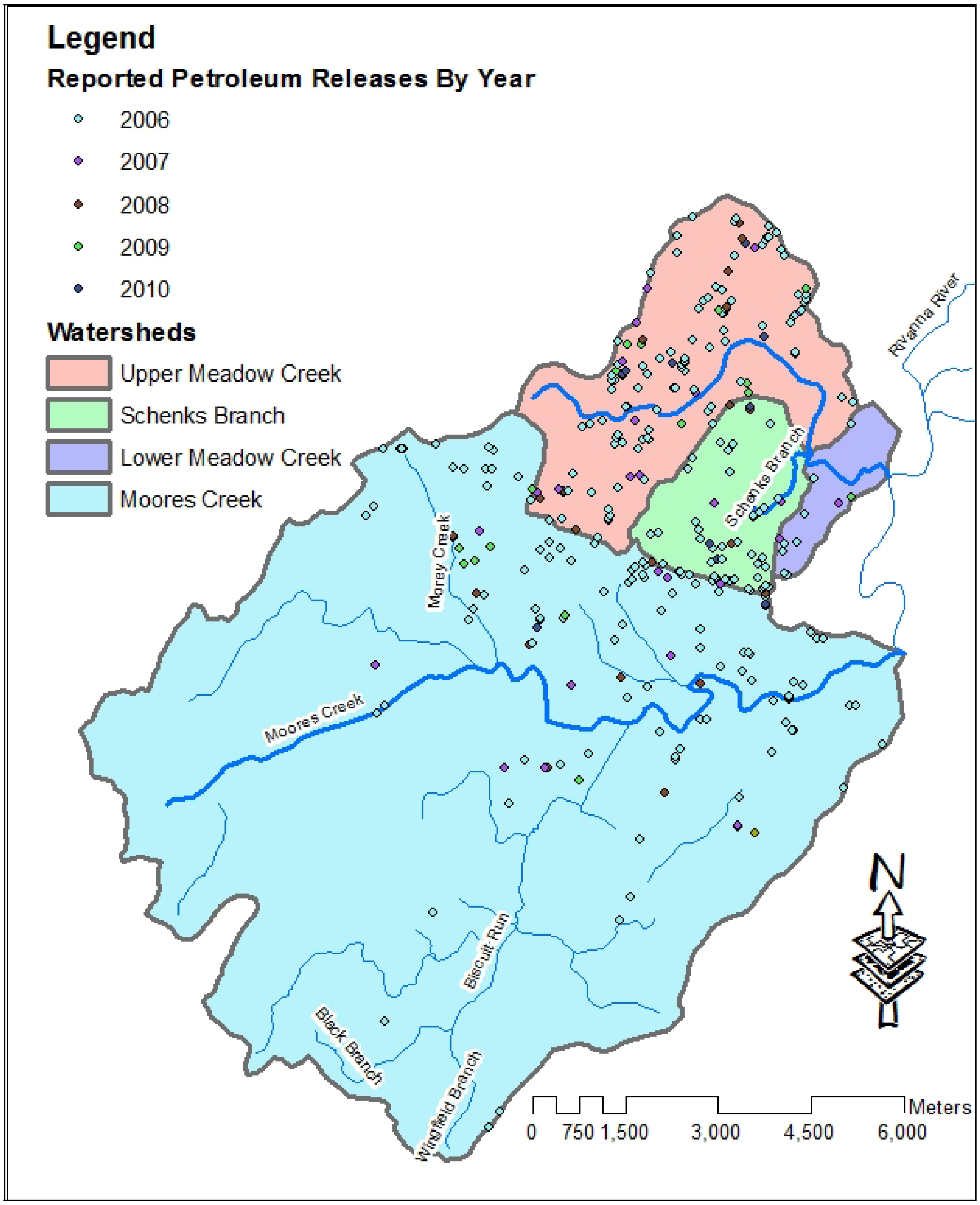

Figure 2-29. Reported Petroleum Releases By Year

Table 2-17. Distribution of Reported Petroleum Releases by Watershed and Year

Watershed	Year				
	pre2007	2007	2008	2009	2010
Upper Meadow Creek	116	12	10	8	5
Schenks Branch	44	2	4	0	3
Lower Meadow Creek	8	2	0	1	0
Moores Creek	111	14	8	7	2
Total	279	30	22	16	10

2.7.5. DEQ Permitted Point Sources

- VAR General Permits
    - There are no general discharge permits for single-family homes in any of the watersheds.
- VPDES Permits
    - Currently, there are 2 active DEQ VPDES permits in the watershed, and an additional 2 permits were active in the recent past. Table 2-18 includes a summary of reported monthly discharges, as required by VPDES permits. Figure 2-30 shows the location of all of the VPDES facilities and DEQ monitoring stations.

Table 2-18. Summary of Monthly Discharge Monitoring Reports from VPDES Facilities

Facility Name	Units	Mean Monthly Measurement	Charlottesville Oil Bulk Plant	Moores Creek STP	Southwoods STP	Virginia Oil
Permit Number		--	VA0051365	VA0025518	VA0029955	VA0087351
Flow	(MGD)	ave	0.0101	9.3	0.0364	0.0010
		max	0.0103	12.8	0.0711	0.0018
TSS	(mg/L)	ave		6.2	37.4	
		max		8.5	40.2	
FC	(no/100 mL)	ave		22.1		
pH		min	6.9	6.2	6.7	6.7
		max	6.9	7.0	7.5	6.7
DO	(mg/L)	min		7.8		
TP	(mg/L)	ave		3.5		
TN	(mg/L)	ave		19.6		
TKN	(mg/L)	ave		5.9		
BOD5	(mg/L)	ave			25.5	
		max			26.6	
CBOD5	(mg/L)	ave		3.8		
		max		7.0		
NH4 Jun-Nov	(mg/L)	ave		0.4		
		max		0.7		
NH4 Dec-May	(mg/L)	ave		1.0		
		max		2.2		
NO2 + NO3, Total	(mg/L)	ave		14.8		
Petroleum Hydrocarbons, Total Recoverable (TPH)	(mg/L)	--	14.2			8.1
No. of Samples		--	48	117	50	110
Beginning Date		--	31-Jan-01	31-Jan-01	31-Jan-01	31-Jan-01
Ending Date		--	30-Nov-05	30-Sep-10	30-Apr-05	30-Sep-10
Receiving Water(s)		--	Moores Cr.	Moores Cr.	Moores Cr.	Schenks Br.

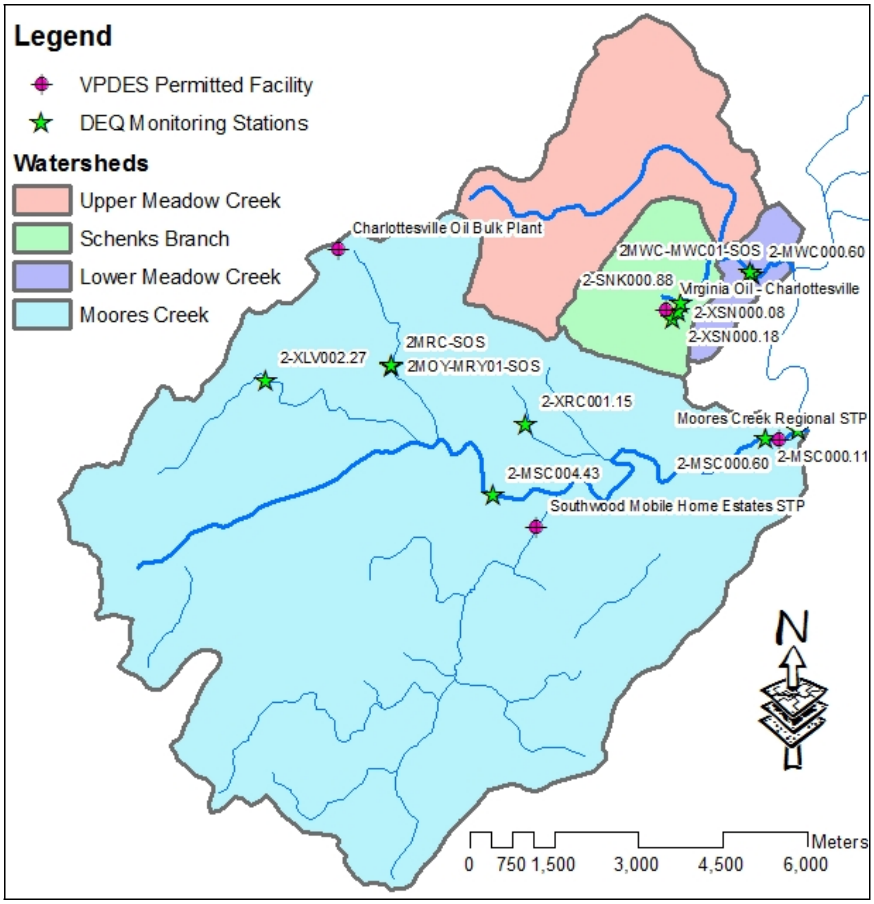

Figure 2-30. VPDES Facilities and DEQ Monitoring Sites

- Industrial Stormwater Permits

As of fall 2010, there were 7 active industrial stormwater permits in the impaired watersheds, shown in Table 2-19. None are listed in Lodge Creek.

Table 2-19. Industrial Stormwater Permits in Moores Creek and Meadow Creek

Permit No	Facility Name	No. of Outfalls	Receiving Stream
VAR051372	University of Va - Parking and Transportation Dept	3	Meadow Creek
VAR050876	Northrop Grumman Systems Corporation	10	Meadow Creek UT
VAR050932	USPS - Charlottesville Vehicle Maint Facility	1	Meadow Creek UT
VAR050974	BFI Waste Servics LLC of Charlottesville	2	Meadow Creek UT
VAR051960	Charlottesville Area Transit-Admin Maint and Oprtn	1	Moores Creek UT
VAR051387	Moores Creek Regional STP	4	Moores Creek
VAR051403	Charlottesville Transit Service	2	Schenks Branch

2.7.6. VCU InStar (**http://instar.vcu.edu**) – Fish Inventory Data

Fish inventory data were limited to two samples taken in 2009, as shown in Table 2-20.

Table 2-20. Summary of Fish Inventory Data

Date	Site Code	Site Description	Types of Fish	No. of fish	Fish Comments	Stream Score	Habitat Score
07/17/09	H28003	Moores Creek	17	174	4 had lesions; 1 had a black spot	78	77
09/09/09	H28011	Unnamed Tributary to Rivanna River	4	94		74	118

2.7.7. 305(b)/303(d) Combined Report Monitored Violations

- Moores Creek: In the earliest three biennial reports between 1998 and 2002 (VADEQ, 1998, 2000, 2002), station 2-MSC000.60 was listed with a bacterial impairment, continuing through the present, with additional bacterial impairments shown downstream at station 2-MSC000.11 and upstream at station 2-MSC004.43. Beginning in 2006, citizen monitoring indicated the possibility of a biological impairment, which was later confirmed at station 2-MSC000.60 in both 2008 and 2010. No violations have been reported for temperature or pH standards. An earlier DO exceeded its standard and several minor total phosphorus concentrations have been flagged at “threatened” levels, as noted with the other data in Table 2-21.

Table 2-21. 305(b) Water Quality Standard Violations – Moores Creek

Monitoring Station	Type	CONVENTIONAL WATER COLUMN MONITORING DATA			OTHER WATER COLUMN DATA				SEDIMENT		FISH TISSUE		BENTHIC		
		#Violations/# Samples/Status							#Violations/Status						
		Temperature	Dissolved Oxygen	pH	Fecal Coliform	E. Coli	Total Phosphorus	Chlorophyll A	Metals	Organics	Metals	Organics	Metals	Organics	Bio Mon
1998															
2-MSC000.60	A	0 / 20 - S	2/20 - S	0 /20 - S	5/18 - P	/ -	/ -	/ -	/	/	0/S	0/S	0/S	/	0
2000															
2-MSC000.60	A	0/22 - S	0/22 - S	0/22 - S	4/19 - P	/ -	/ -	/ -	/	/	0/W	0/W	/	/	0
2002															
2-MSC000.60	A	0/26 - S	0/26 - S	0/26 - S	4/23 - P	/ -	0/24 - S	/ -	0/S	0/S	0/S	0/S	/	/	0
2004															
2-MSC000.60	A	0/29 - S	0/29 - S	0/29 - S	6/27 - IM	/ -	/ -	/ -	/	0/S	/	/	/	/	LP
2MSC-1-SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	MP
2006															
2MSC000.11	A	0/1 - W	0/1 - W	0/1 - W	/ -	/ -	/ -	/ -	/	0/S	0/S	/	/	/	MI
2MSC000.60	A	0/22 - S	0/22 - S	0/22 - S	2/20 - S	/ -	1/21 - S	0/10 - S	/	0/S	0/S	/	/	/	MP
2MSC1SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	MP
2MSC4SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	LP
2008															
2-MSC000.11	A	0/1 - W	0/1 - W	0/1 - W	/ -	/ -	/ -	/ -	/	0/S	/	/	/	/	HP
2-MSC000.60	A,B	0/34 - S	0/31 - S	0/33 - S	9/33 - W	/ -	1/15 - W	0/10 - W	/	0/S	0/S	/	/	/	IM
2-MSC004.43	A	0/9 - S	0/9 - S	0/8 - S	/ -	/ -	0/9 - W	/ -	/	/	0/S	/	/	/	IM
2010															
2-MSC000.11	A	0/1 - W	0/1 - W	0/1 - W	/ -	/ -	/ -	/ -	0/S	/	/	/	/	/	IM
2-MSC000.60	A,B	0/34 - S	0/31 - S	0/33 - S	/ -	13/28 - IM	/ -	/ -	0/S	0/S	/	/	/	/	IM
2-MSC004.43	A	0/9 - S	0/9 - S	0/8 - S	/ -	3/9 - IM	/ -	0/3 - NA	/	0/S	/	/	/	/	HP
2-MSC-4-SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	HP
2-MSC-MSC04-SW	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	IM

- <u>Lodge Creek</u>: The 2010 Fact Sheet for Impaired Waters identifies the initial listing date for this segment as 2006, although that fact is not reflected in the 305(b) biomonitoring results shown below in Table 2-22, which show an initial impaired (IM) rating in 2010. Citizen monitoring played a role in getting the stream segment listed. No violations have been reported for temperature, DO, or pH standards. No total phosphorus concentrations have reached “threatened” levels. No ambient monitoring is available for this station.

Table 2-22. 305(b) Water Quality Standard Violations – Lodge Creek

Monitoring Station	Type	CONVENTIONAL WATER COLUMN MONITORING DATA			OTHER WATER COLUMN DATA				SEDIMENT		FISH TISSUE		BENTHIC		
		#Violations/# Samples/Status							#Violations/Status						
		Temperature	Dissolved Oxygen	pH	Fecal Coliform	E. Coli	Total Phosphorus	Chlorophyl l A	Metals	Organics	Metals	Organics	Metals	Organics	Bio Mon
2004															
2-XRC001.15		0/4 - S	0/4 - S	0/4 - S	/ -	/ -	/ -	/ -	/	/	/	/	/	/	0
2006															
2XRC001.15	B	0/3 - S	0/3 - S	0/3 - S	/ -	/ -	/ -	/ -	/	/	/	/	/	/	0
2008															
2-XRC001.15	B	0/3 - S	0/3 - S	0/3 - S	/ -	/ -	/ -	/ -	/	/	/	/	/	/	0
2010															
2-XRC001.15	B	0/1 - W	0/1 - W	0/1 - W	/ -	/ -	/ -	/ -	/	/	/	/	/	/	IM
2-XRC-XRC01-SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	0
2-XRC-XRC01-SW	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	0

- Meadow Creek: Citizen monitoring led to the initial listing of this stream segment as a benthic impairment in 2006, as shown in Table 2-23Table 2-23. The impairment continued to show impairment in the DEQ biological samples for the 2008 and 2010 assessments. The Meadow Creek bacteria impairment was included in the Rivanna River Bacteria TMDL. No violations have been reported for temperature or pH standards violations, although 1 DO violation occurred prior to 1998. No total phosphorus concentrations have reached "threatened" levels.

Table 2-23. 305(b) Water Quality Standard Violations – Meadow Creek

		CONVENTIONAL WATER COLUMN MONITORING DATA			OTHER WATER COLUMN DATA				SEDIMENT		FISH TISSUE		BENTHIC		
		#Violations/# Samples/Status							#Violations/Status						
Monitoring Station	Type	Temperature	Dissolved Oxygen	pH	Fecal Coliform	E. Coli	Total Phosphorus	Chlorophyll A	Metals	Organics	Metals	Organics	Metals	Organics	Bio Mon
1998															
2-MWC000.60	A	0 / 22 - S	1/22 - S	0/ / 22 - | S	3/19 - T	/ -	/ -	/ -	/	/	0/S	0/S	0/S	/	0
2000															
2-MWC000.60	A	0/22 - S	0/22 - S	0/22 - S	2/19 - T	/ -	/ -	/ -	/	/	0/W	0/W	/	/	0
2002															
2-MWC000.60	A	0/26 - S	0/26 - S	0/26 - S	4/23 - P	/ -	0/24 - S	/ -	/	/	0/S	0/S	/	/	0
2MWC-8-SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	MP
2MWC-SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	LP
2004															
2-MWC000.60	A	0/19 - S	0/19 - S	0/19 - S	7/18 - IM	/ -	/ -	/ -	0/S	0/S	/	/	/	/	LP
2MWC-3-SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	0
2MWC-8B-SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	LP
2MWC-8-SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	LP
2MWC-SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	MI
2006															
2MWC000.60	A	0/20 - S	0/20 - S	0/20 - S	3/8 - IM	/ -	0/18 - S	/ -	/	/	0/S	/	/	/	0
2MWC3SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	LP
2MWC8SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	MI
2MWCSOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	LP
2008															
2-MWC000.60	A,B	0/16 - S	0/15 - S	0/16 - S	1/3 - W	/ -	0/15 - W	/ -	/	/	0/S	/	/	/	IM
2MWC-MWC01-SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	IM
2010															
2-MWC000.60	A,B	0/1046 - S	/ - S	0/36 - S	/ -	12/26 - IM	/ -	/ -	0/S	0/S	0/S	0/S	/	/	IM
2-MWC-3-SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	0/1 - NA	/	/	/	/	/	/	0
2-MWC-MWC01-SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	MP
2-MWC-MWC01-SW	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	IM
2-MWC-MWC03-SW	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	IM

- Schenks Branch: Schenks Branch was initially listed with a benthic impairment in 2008 according to the 2010 TMDL Fact sheets, but the 305(b)/303(d) data only identify the impairment in 2010 as shown in Table 2-24, both on its main channel and at two unnamed tributary stations. The Schenks Branch bacteria impairment was not monitored prior to development of the Rivanna River Bacteria TMDL, but is subject to reductions applicable to Meadow Creek. No violations have been reported for temperature, DO, or pH standards violations. No total phosphorus samples have been analyzed at these sites.

Table 2-24. 305(b) Water Quality Standard Violations – Schenks Branch

Monitoring Station	Type	CONVENTIONAL WATER COLUMN MONITORING DATA			OTHER WATER COLUMN DATA				SEDIMENT		FISH TISSUE		BENTHIC		
		#Violations/# Samples/Status							#Violations/Status						
		Temperature	Dissolved Oxygen	pH	Fecal Coliform	E. Coli	Total Phosphorus	Chlorophyll A	Metals	Organics	Metals	Organics	Metals	Organics	Bio Mon
2002															
2SNK-SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	MP
2004															
2SNK-SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	0
2008															
2-SNK000.88	A,B	0/1 - W	0/1 - W	0/1 - W	/ -	/ -	/ -	/ -	/	/	/	/	/	/	0
2-XSN000.08	A,B	0/1 - W	0/1 - W	0/1 - W	/ -	/ -	/ -	/ -	/	/	/	/	/	/	0
2-XSN000.18	A,B	0/1 - W	0/1 - W	0/1 - W	/ -	/ -	/ -	/ -	/	/	/	/	/	/	0
2010															
2-SNK000.88	A,B,CR	0/1016 - S	/ - S	0/13 - S	/ -	3/3 - IM	/ -	/ -	/	0/S	0/S	0/S	/	/	HP
2-SNK-SHK01-SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	LP
2-SNK-SHK02-SW	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	IM
2-SNK-SHV01-SW	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	IM
2-SNK-SOS	CMON	/ -	/ -	/ -	/ -	/ -	/ -	/ -	/	/	/	/	/	/	IM
2-XSN000.08	A,B,CR	0/8 - S	0/8 - S	0/8 - S	/ -	5/6 - IM	/ -	/ -	/	0/S	/	/	/	/	0
2-XSN000.18	B	0/1 - W	0/1 - W	0/1 - W	/ -	/ -	/ -	/ -	/	/	/	/	/	/	IM

2.7.8. Virginia DCR Data

- Agricultural BMP Cost-Share Data: Only one agricultural BMP, a CREP riparian forest buffer (CRFR-3), was reported as being active and installed with state or federal cost-share money in any of these watersheds.

Table 2-25. Installed Agricultural BMPs from DCR Cost-Share Database

BMP Type	Area Installed (ac)	Area benefitted (ac.)	Date Installed	Practice Life (yrs)	12-Digit HUC	Watershed Name
CRFR-3	21.3	21.3	Apr-04	15	JR15	Moores Creek

- Virginia Stormwater Management Program (VSMP) Permits

The VSMP permits include those related to temporary construction as listed in Table 2-26, as well as permits under the Municipal Separate Storm Sewer System (MS4) Program issued to Albemarle County, the City of Charlottesville, the University of Virginia, the Virginia Department of Transportation, and Piedmont Virginia Community College.

Table 2-26. Virginia Stormwater Management Program (VSMP) Construction Permit Summary

VAR Permit Number	Activity Name	Receiving Water(s)	Est Project Start Date	Est Project End Date	Total Land Area (ac)	Disturbed Area (ac)
Moores Creek Permits						
VAR10-10-101860	Avon Park Subdivision	Biscuit Run UT (Moores Cr.)	01-Jan-07		5	5
VAR10-11-100521	Piedmont Virginia Community College - Parking Lot Expansion - Commercial	Biscuit Run/Moores Creek	11-Oct-10	30-Jan-11	2.1	2.1
VAR10-10-100232	Claude Moore Medical Education Building Project	Moores Creek	01-Jan-08	30-Apr-10	1.1	1.1
VAR10-10-101226	Habitat for Humanity - Nunley St.	Moores Creek	15-Sep-07	31-Dec-10	2.7	2.2
VAR10-10-100506	Huntley Subdivision PUD	Moores Creek	03-Jan-04	03-Jan-11	22.8	17.1
VAR10-10-103459	Moores Creek Wastewater Treament Plant - Industrial Infrastructure; Expansion/Improvements of a Wastewater	Moores Creek	01-Sep-09	30-Jun-14	89.5	12
VAR10-10-102595	Piedmont Virginia Community College	Moores Creek	10-Nov-08	11-Mar-10	37.43	2.7
VAR10-10-100019	Ragged Mountain Water main replacement Phase 2 and 3	Moores Creek	20-Apr-09	20-Oct-09	1.4	1.4
VAR10-10-100581	Sieg Warehouse	Moores Creek	27-Mar-09	24-Jul-09	2.9	1.76
VAR10-10-100864	South Lawn Project	Moores Creek	01-May-07		0	5.5
VAR10-11-100543	Stadium Road Sanitary Sewer Collector Rehabilitation Phase II & III - Municipal Sanitary Sewer Replacement/Upgrade	Moores Creek	01-Oct-10	31-Aug-11	11.1	11.1
VAR10-10-104400	University of Virginia - University Data Center - Commercial	Moores Creek	01-Apr-10	01-Apr-10	1.3	1.3
VAR10-10-101429	Forest Hill Park	Moores Creek UT	18-May-09	18-Dec-09	7.4	5.9
VAR10-10-100907	UVA - CAS and ITE Buildings	Moores Creek UT	24-Nov-08	01-Dec-11	3.9	3.9
VAR10-10-101452	UVA Long Term Acute Care Hospital	Morey Creek UT (Moores Cr.)	17-Feb-09	10-Sep-10	8.5	2.6
VAR10-10-102277	Brookwood	Rock Creek (Moores Cr.)	01-Aug-06	30-Jul-10	12.72	12
VAR10-10-103169	Rock Creak Villages - Residential	Rock Creek (Moores Cr.)	30-Sep-09	01-Jan-11	4.05	1.05
VAR10-10-102980	Buford Middle School Campus	Rock Creek UT (Moores Cr.)	01-Jun-09	01-Sep-10	18.09	1.09
Lodge Creek Permits						
VAR10-10-104882	University of Virginia - Alderman Road Housing Phase III Utilities	Lodge Creek	24-May-10	11-Aug-10	2.2	2.2
VAR10-10-102543	University of Virginia	Lodge Creek	30-Jun-09	30-Aug-12	4.6	4.6
Meadow Creek Permits						
VAR10-10-103013	Meadow Creek Parkway Replacement - Sewer Replacement/Upgrade	Meadow Creek	01-Aug-09	01-Dec-10	5.09	5.09
VAR10-10-104009	Meadow Creek Sanitary Sewer Interceptor Upgrade Design - Contract B - Sewer Replacement/Upgrade	Meadow Creek	01-Dec-09	30-Dec-11	13.15	13.15
VAR10-10-104086	St. Anne's - Belfield School - Commercial	Meadow Creek	01-Apr-09	30-Sep-10	13.7	13.7
VAR10-10-102424	UVA - Bavaro Hall	Meadow Creek	01-May-08	15-May-10	2.38	2.38
VAR10-10-103872	Abbington Crossing - Clubhouse Replacement - Replacement of an Existing Apartment Clubhouse, Swimming Pool & Playground	Meadow Creek UT	19-Oct-10	31-May-10	2	0.8
VAR10-10-103802	Hillsdale Drive Extended - Commercial	Meadow Creek UT	01-Nov-09	01-May-10	14.6	8.3
VAR10-10-104445	Red Lobster - Commercial Construction of a New Restaurant	Meadow Creek UT	15-Mar-10	30-Jun-10	2.13	2.5
VAR10-11-100300	Treesdale Park - Residential	Meadow Creek UT	15-Aug-10	15-Aug-11	6.6	5.9
VAR10-10-103098	University of Virginia - Band Rehearsal Hall - Educational Bldg - New Construction	Meadow Creek UT	10-Nov-09	01-Dec-10	1.05	1.05
VAR10-10-103803	Whole Foods Market - Commercial	Meadow Creek UT	01-Nov-09	01-May-10	3.76	4.09
VAR10-10-101596	Northfields	Town Branch Creek (Meadow Cr.)	23-Mar-09	30-Sep-09	13.5	1.6
Schenks Branch Permits						
VAR10-10-104284	Wellington Court - Residential	Schenks Branch	01-Jun-11	01-Jul-12	1.4	1.3
VAR10-10-104008	Meadow Creek Sanitary Sewer Interceptor Upgrade Design - Contract A - Sewer Replacement/Upgrade	Schenks Branch/Meadow Creek	01-Dec-09	30-Apr-11	14.31	14.31

2.7.9. Local Sources of Information

Several sources of local information were also considered in the stressor analysis, including stream corridor assessments (SCAs) that were conducted by Albemarle County in 2002, and by the City of Charlottesville in 2005 (Table 2-27), and a companion habitat assessment by the County (Table 2-28). Another interesting source of local information was a series of YouTube videos produced by a local citizen titled "Charlottesville City of Trash" that highlighted problems in Lodge Creek, Rock Creek, and Moores Creek. The videos highlight sewer system overflows to Lodge Creek, leaching from the Avon sanitary landfill (closed in 1974), illegal dumping, and impacts on channel stability from urban runoff. The videos are available at: http://www.youtube.com/watch?v=KgXewYjz5Xg&feature=related.

Table 2-27. Stream Corridor Assessment (SCA) - Summary of Potential Problems, 2005

Stream	Receiving Stream	Length of Reach (ft)	Reach Code	Insufficient Buffers	Crossings	Dump Sites	Erosion Sites	Obstruc-tions	Pipes/ Ditches	Public Utilities
City of Charlottesville Stream Corridor Asssessment, 2005										
Lodge Creek	Moores Creek	6,165	LOD	67	10	2	78	19	31	29
Pollock's Branch	Moores Creek	2,682	POL	32	12	0	42	8	10	19
Rock Creek	Moores Creek	4,985	ROC	9	11	5	77	0	41	6
Schenk's Branch	Meadow Creek	6,526	SC1	53	10	1	82	22	96	21
St. Charles Creek	Meadow Creek	2,763	STC	18	13	0	41	16	19	7
Albemarle County Stream Corridor Assessment, 2002										
Between Biscuit&MHS	Moores Creek	3,225	BBM	0	2	1	1	0	4	0
Biscuit Run	Moores Creek	38,753	BIS	6	7	5	3	0	1	2
Branchlands/Berkeley	Meadow Creek	5,832	BRB	4	4	0	2	2	17	2
Cow Branch/MHS	Moores Creek	21,386	COW	5	17	0	2	3	12	4
Meadow Creek Above Branchlands	Meadow Creek	7,784	MAB	1	8	3	4	1	15	3
Meadow Creek Below Branchlands	Meadow Creek	12,567	MBB	4	5	0	5	0	10	10
Moores Creek Above Biscuit	Moores Creek	17,109	MOA	9	12	0	3	2	13	7
Moores Creek Below Biscuit	Moores Creek	19,372	MOB	10	5	4	3	2	14	7
Morey Creek	Moores Creek	32,710	MOR	8	14	1	6	0	1	5
Ragged Mtn Creek	Moores Creek	10,839	RMC	1	5	1	0	1	8	4
City Totals		**23,121**		**179**	**56**	**8**	**320**	**65**	**197**	**82**
County Totals		**169,577**		**48**	**79**	**15**	**29**	**11**	**95**	**44**

Table 2-28. Stream Corridor – Habitat Assessment, Albemarle County (2002)

Stream Segment	Receiving Stream	Epifaunal substrate/Available Cover	Embeddedness	Velocity/Depth Regime	Sediment deposition	Frequency of riffles	Channel alteration	Frequency of riffles	Bank stability (left bank)	Bank stability (right bank)	Bank vegetative protection (left bank)	Bank vegetative protection (right bank)	Vegetatated buffer zone width (left bank)	Vegetatated buffer zone width (right bank)
Between Biscuit&MHS	Moores Creek	11	13.5	7.5	14	12	12	8.5	3	3	3.5	3.5	6	6
Biscuit Run	Moores Creek	11.4	10.9	9.1	9.8	12.8	15.4	10.1	5.6	5.9	6.1	6.2	7	8
Branchlands/Berkeley	Meadow Creek	12	14	11.7	13.3	14.3	12	13	7	6.3	7.3	6.3	5.3	5
Cow Branch/MHS	Moores Creek	12.2	11.2	10.8	11.2	13.7	13.7	13.2	6.2	6.2	5.8	5.8	3.7	3.8
Meadow Creek Above Branchlands	Meadow Creek	10.7	9.3	9.3	8.7	10	14	10.3	4	4	5	5	6.3	8
Meadow Creek Below Branchlands	Meadow Creek	11	9.2	10	9.7	11.7	12.2	10.5	4.3	4.3	4	5.2	6.3	8
Moores Creek Above Biscuit	Moores Creek	12.6	8.6	13.1	9	13.4	14.4	10.4	6.6	6.6	6.9	6.7	6.7	5.4
Moores Creek Below Biscuit	Moores Creek	12.4	10.2	16	8.2	13.2	12.2	11.6	6.6	6	6	6	3.8	5.8
Morey Creek	Moores Creek	9.3	8.1	7.9	7.9	12.6	10.1	9.2	5.2	5.9	4.9	5.2	4.2	5
Ragged Mtn Creek	Moores Creek	11.2	10.5	10.7	9	15.2	14.7	11.5	5.8	5.8	6.5	6.5	6.8	6

- "Poor" or "Marginal" habitat score.

A 1998 State of the Basin report from the Thomas Jefferson Planning District Commission also provided this information on Meadow Creek, which was one of eight stations in the report for which morphological measurements were taken in conjunction with chemical and biological monitoring:

> "This river segment is entrenched with a high width/depth ratio. Particle distribution is bimodal with peaks in the silt/clay, sand, and cobble ranges. This segment classifies as a Rosgen F4 stream. Meadow Creek presents an interesting case: the particle distribution is among the healthiest in the basin with good representation of particles in both the gravel and cobble ranges. At a glance, one may assume that aquatic habitat availability is good here. However, given the highly urbanized nature of the watershed, habitat availability may not be the limiting factor, as evidenced by low SOS scores. Entrenchment is one of the lowest in the basin, with steep muddy and silty banks, characteristic of urban hydrology. This urban type hydrology, with quick, steep storm hydrographs, appears to be transporting sediment bedload sufficiently through rapids and runs, based on the particle distribution (this is a kind of urban "flushing" effect). A take-home message for Meadow Creek may be that, given a relatively good streambed structure, the creek

may be an excellent candidate for restoration if water quality issues can be addressed" (TJPDC, 1998).

2.7.10. Related TMDLs and/or Implementation Plans

The following are other TMDLs and implementation plans which also affect the four benthic-impaired stream segments that are the subject of this report. Findings from these studies, and actions planned may have relevance and benefit for sediment reductions resulting from these TMDLs.

- 2002: Moores Creek Fecal Coliform TMDL
    - http://www.deq.virginia.gov/tmdl/apptmdls/jamesrvr/moorecr3.pdf
- 2005: Moores Creek Fecal Coliform TMDL Implementation Plan
    - http://www.deq.virginia.gov/export/sites/default/tmdl/implans/mooresip.pdf
- 2008: Benthic TMDL Development for the Rivanna River Watershed (sediment)
    - http://www.deq.virginia.gov/tmdl/apptmdls/jamesrvr/rivannabc.pdf
    - Temp, DO, and pH not stressors; metals and organics generally low; P and toxicity – possible stressors; sediment and embeddedness were suboptimal and confounded by increased runoff from urban areas.
    - Upper portions of watershed have unstable streambanks and modified hydrology.
    - RBS results on Rivanna mainstem similar to those in Meadows and Schenks.
- 2009: Bacteria TMDL Development for the Rivanna River Mainstem, North Fork Rivanna River, Preddy Creek and Tributaries, Meadow Creek, Mechums River, and Beaver Creek Watersheds
    - http://www.deq.virginia.gov/tmdl/apptmdls/jamesrvr/rivannaec.pdf

2.7.11. Sanborn Insurance Maps

- Historic Sanborn Insurance Maps were reviewed for the City of Charlottesville to investigate potential legacy sources of PAH compounds in Schenks Branch (http://sanborn.umi.com).
- The 1929 and 1929-1950 maps showed development around Schenks Branch that included 3-4 oil and gas companies and 2 refineries located on Harris St. between Rivanna Ave. and Concord Ave.
- The 1920 map does not show any of these companies being in place. Also, no additional maps exist beyond 1950 but current Google maps show none of these companies are still in existence at the specified locations, although the location of the VPDES permit for Virginia Oil is in this general area.
- There is currently a heating oil company (GOCO Oil) located on Harris St. near Concord Ave., and a concrete company (Allied Concrete) located on Harris St.

CHAPTER 3: BENTHIC STRESSOR ANALYSIS

3.1. Introduction

TMDLs must be developed for a specific pollutant. Since a benthic impairment is based on a biological inventory, rather than on a physical or chemical water quality parameter, the pollutant is not explicitly identified in the assessment, as it is with physical and chemical parameters. The process outlined in USEPA's Stressor Identification Guidance Document (USEPA, 2000) was used to identify the critical stressor for each of the impaired watersheds in this study. A list of candidate causes was developed from the listing information, biological data, published literature, and stakeholder input. Chemical and physical monitoring data from DEQ monitoring provided additional evidence to support or eliminate the potential candidate causes. Biological metrics and habitat evaluations in aggregate provided the basis for the initial impairment listing, but individual metrics were also used to look for links with specific stressors, where possible. Volunteer monitoring data, land use distribution, Virginia Base Mapping Project (VBMP) aerial imagery, and visual assessment of conditions in and along the stream corridor provided additional information to investigate specific potential stressors. Logical pathways were explored between observed effects in the benthic community, potential stressors, and intermediate steps or interactions that would be consistent in establishing a cause and effect relationship with each candidate cause. The information in this chapter is adapted from the original Stressor Analysis Report for Moores Creek, Lodge Creek, Meadow Creek, and Schenks Branch presented to the Technical Advisory Committee on January 6, 2011 and the revision distributed on June 14, 2011.

3.2. Analysis of Stressors for Moores Creek

The suspected sources of the benthic impairment in Moores Creek were listed as Municipal (Urbanized High Density Area) and Non-Point Source in the 2010 List of Impaired Waters. The primary DEQ monitoring station for both ambient and biological monitoring is 2-MSC000.60. In order to further discriminate sources, a stressor analysis was performed on all available data. The stressor may be something that either directly affected the benthic community or indirectly affected its habitat. Virginia SCI ratings suggest that the benthic community has been severely impaired in the two samples taken in October 2006 and March 2008.

A list of candidate stressors was developed for Moores Creek and evaluated to determine the pollutant(s) responsible for the benthic impairment. A potential stressor checklist was used to evaluate known relationships or conditions that may show associations between potential stressors and changes in the benthic community. Available evidence was then summarized for each potential stressor. Depending on the strength of available evidence, the potential stressors were either "eliminated", considered as "possible" stressors, or recommended as the "most probable" stressor(s). Candidate stressors included ammonia, hydrologic modifications, metals, nutrients, organic matter, PAHs, pH, sediment, TDS/conductivity/sulfates, temperature, and toxics. The evaluation of each candidate stressor is discussed in the following sections.

3.2.1. Eliminated Stressors

- **Ammonia**

  High values of ammonia are toxic to many fish species and may impact the benthic community as well. Although values were occasionally as high as 0.11 mg/L, most of the values recorded at DEQ ambient monitoring stations were at or below the minimum detection limit (MDL) of 0.04 mg/L and, therefore, ammonia was eliminated from further consideration as a stressor for Moores Creek.

- **Metals**

Increased metals concentrations lead to low diversity and low total abundance of benthic organisms, with specific reduced abundance of metal-sensitive mayflies and increased abundance of metal-tolerant chironomids (Clement, 1994). Total organism abundance was moderate with hydropsychidae and chironomidae dominating other organisms. Although these may be associated with elevated metals, no water column concentrations were found that violated either their chronic freshwater or public water supply standards, and no sediment concentrations exceeded their sediment PECs. Therefore, metals were eliminated from further consideration as a possible stressor.

- **pH**

Benthic macroinvertebrates require a specific pH range of 6.0 to 9.0 to live and grow. Changes in pH may adversely affect the survival of benthic macroinvertebrates. Treated wastewater, mining discharge and urban runoff can potentially alter in-stream levels of pH. No violations of the minimum or maximum pH standard were reported at any of the DEQ stations on the impaired segment. Therefore, pH was eliminated from further consideration as a stressor.

- **TDS/Conductivity/Sulfates**

Total dissolved solids (TDS) are the inorganic salts, organic matter and other dissolved materials in water. Elevated levels of TDS cause osmotic stress and alter the osmoregulatory functions of organisms (McCulloch et al., 1993). The average TDS and conductivity measurements reported in DEQ monitoring data for Moores Creek watershed were all considerably lower than the reference watershed screening values of 500 mg/L and 500 µmhos/cm, respectively. Therefore, this suite of stressors was eliminated from further consideration as a possible stressor.

- **Temperature**

Elevated temperatures can stress benthic organisms and provide sub-optimal conditions for their survival. Moores Creek is classified as a Class III Non-tidal Piedmont and Coastal stream with a maximum temperature standard of 32°C. No violations of the temperature standard were recorded by DEQ ambient monitoring, or by monitoring during collection of the biological samples. Low riparian vegetation habitat metric scores were observed during one biological sampling, but did not correspond with elevated temperature levels. Therefore, no evidence supported temperature as a stressor, and it was eliminated.

3.2.2. Possible Stressors

- **Hydrologic Modifications**

Hydrologic modifications can cause shifts in the supply of water, sediment, food supply, habitat, and pollutants from one part of the watershed to another, thereby causing changes in the types of biological communities that can be supported by the changed environment. Several of the tributaries of Moores Creek near the outlet contain large concentrations of urban, impervious areas, which contribute to modified hydrology in a watershed. Several other tributaries contain minor impoundments, though these are far removed from the main channel and the outlet. Although these modifications are considered as “pollution” and not “pollutants” covered by the TMDL legislation, hydrologic modifications are considered a possible stressor as they are likely to increase channel erosion and sediment loads downstream.

- **Nutrients**

Excessive nutrient inputs can lead to excessive algal growth, eutrophication, and low dissolved oxygen concentrations which may adversely affect the survival of benthic macroinvertebrates. In particular, dissolved oxygen levels may become low during overnight hours due to plant respiration.

The benthic community in Moores Creek can be characterized as being dominated by Chironomidae and Hydropsychidae – organisms possibly associated with excessive nutrients - and has a low diversity, with these two organisms comprising more than 70% of each sample. Dissolved N and P concentrations are above eutrophication sufficiency levels in lakes, and several samples have exceeded DEQ's "threatened water" TP levels. Downstream from the STP, nutrient levels have been exceedingly high, although these are not responsible for the upstream impairment. Furthermore, the Moores Creek STP has been reissued a VPDES permit, effective August 1, 2011, that requires considerable reductions to meet its new average annual concentration limits of 0.5 mg/L TP and 6.0 mg/L TN. Since, however, there were no recorded instances of DO standard violations, nutrients are only considered to be a possible stressor and downstream concentrations will be considerably reduced when the STP comes into compliance with its new limits.

- **Organic Matter**

Excessive organic matter can lead to low in-stream dissolved oxygen concentrations, which may adversely affect the survival and growth of benthic macroinvertebrates. Potential sources of organic matter in Moores Creek include sewer system overflows, runoff from manured agricultural areas, and runoff from impervious areas. Organic enrichment is supported by the moderate to high values of the Modified Family Biotic Index (MFBI) and the abundance of Hydropsychidae and Simuliidae – typical of organic-enriched sites. On the other hand, the levels of BOD_5, TOC, and COD are all very low; there have been no monitored DO standard violations; there were low levels of TKN to TN in 2007 at the biological monitoring site; and the low % scrapers and the low numbers of filterer-collector organisms in the first sample do not support organic matter as being excessive, although the % of filterer-collectors increased considerably in the second sample. High levels of TKN relative to TN were observed in the 1970's downstream from the sewage treatment plant (STP), but these measurements were downstream from where the biological monitoring occurred and were most likely attributable to the STP. Therefore, organic matter is considered to be a possible stressor, but probably not the most likely one causing the original impairment.

- **PAHs**

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous contaminants derived from fossil fuels and their incomplete combustion. Some are highly potent carcinogens. PAHs generally occur as mixtures of tens to hundreds of related hydrocarbon compounds. While individual PAHs can cause toxicity at certain levels, cumulative effects from multiple compounds at lower levels are also suspected of causing toxicity. PAHs have been detected in the one sample taken in September 2010, but none of the compounds exceeded their PECs, indicative of levels that could cause toxicity; nor did it have a Mean-PEC Quotient that would indicate the possibility of cumulative toxicity. Therefore, because these substances have been detected, they are listed as possible, but not probable sources.

- **Toxics**

Toxic substances by definition are not well tolerated by living organisms. The presence of toxics as a stressor in a watershed may be supported by very low numbers of any type of organisms, low organism diversity, violations of freshwater aquatic life criteria or consensus-based PECs for metals or inorganic compounds, by low percentages of the shredder population, reports of fish kills, or by the presence of available sources. Since there are known historical and current point source (PS) dischargers, one with petroleum-related discharges, and a low percentage of shredders present, toxicity is a possibility. However, there are abundant organisms present, including observed fish, and no violations of sediment-related PECs or in-stream Aquatic Life Use criteria for metals or PAHs. Because of the presence of some of these sources, toxics are considered to be a possible stressor, but certainly not the most likely one.

3.2.3. Most Probable Stressors

The most probable stressor to the benthic community is considered to be sediment based on the following summary of available evidence.

- **Sediment**

  Excessive sedimentation can impair benthic communities through loss of habitat. Excess sediment can fill the pores in gravel and cobble substrate, eliminating macroinvertebrate habitat. Potential sources of sediment include residential runoff, forest harvesting operations, construction sites, and in-stream disturbances.

  Sediment loads may arise from agricultural runoff, livestock with stream access, barren areas, construction sites, and forest harvesting, but channel erosion from unstable banks and washoff from impervious areas are the most obvious contributors. Sediment is supported as a stressor for this impairment through the poor habitat metrics related to sediment including embeddedness and bank stability. Ambient TSS concentrations are low, but no storm samples were taken to check for higher concentrations expected during storm events. The Albemarle County Stream Corridor Assessment in 2002 also noted many riparian sites along Moores Creek and many tributaries with insufficient buffer and active erosion, and poor habitat metrics related to bank stability and bank vegetation. Sediment is considered the most probable stressor in Moores Creek because of the poor habitat metrics related to sediment and the inventory of areas with poor vegetative cover and bank stability.

3.3. Analysis of Candidate Stressors for Lodge Creek

The suspected source of the benthic impairment in Lodge Creek was listed as Non-Point Source in the 2010 List of Impaired Waters. The DEQ biological station on this stream segment is 2-XRC001.15. There is no DEQ ambient monitoring on this stream segment. In order to further discriminate sources, a stressor analysis was performed on all available data. The stressor may be something that either directly affected the benthic community or indirectly affected its habitat. Virginia SCI ratings suggest that the benthic community has been severely impaired throughout the period from 2002 to 2009.

A list of candidate stressors was developed for Lodge Creek and evaluated to determine the pollutant(s) responsible for the benthic impairment. A potential stressor checklist was used to evaluate known relationships or conditions that may show associations between potential stressors and changes in the benthic community. Available evidence was then summarized for each potential stressor. Depending on the strength of available evidence, the potential stressors were either “eliminated”, considered as “possible” stressors, or recommended as the “most probable” stressor(s). Candidate stressors included ammonia, hydrologic modifications, metals, nutrients, organic matter, pH, sediment, TDS/conductivity/sulfates, temperature, and toxics. The evaluation of each candidate stressor is discussed in the following sections.

3.3.1. Eliminated Stressors

- Ammonia

High values of ammonia are toxic to many fish species and may impact the benthic community as well. While there are no DEQ ambient monitoring stations on Lodge Creek, all recorded values monitored downstream on Moores Creek were at or below the minimum detection limit (MDL) of 0.04 mg/L and, therefore, it was eliminated as a stressor for Lodge Creek.

- Metals

Increased metals concentrations lead to low diversity and low total abundance of benthic organisms, with specific reduced abundance of metal-sensitive mayflies and increased abundance of metal-tolerant chironomids (Clement, 1994). Total organism abundance was moderate with either hydropsychidae or chironomidae organisms dominating each sample. Although these may be associated with elevated metals and no samples were taken on Lodge Creek itself, no water column or sediment concentrations were found downstream in Moores Creek that exceeded their respective public water supply standards or sediment PECs. Therefore, metals were eliminated as a possible stressor.

- pH

Benthic macroinvertebrates require a specific pH range of 6.0 to 9.0 to live and grow. Changes in pH may adversely affect the survival of benthic macroinvertebrates. Treated wastewater and urban runoff can potentially alter in-stream levels of pH. No violations of the minimum or maximum pH standard were reported for any field measurements taken at the time of each biological sample. Therefore, pH was eliminated from further consideration as a stressor.

- TDS/Conductivity/Sulfates

Total dissolved solids (TDS) are the inorganic salts, organic matter and other dissolved materials in water. Elevated levels of TDS cause osmotic stress and alter the osmoregulatory functions of organisms (McCulloch et al., 1993). The field conductivity values measured concurrently with the biological samples taken in Lodge Creek were all considerably lower than the reference watershed screening values of 500 µmhos/cm. Therefore, this suite of stressors was eliminated from further consideration as a possible stressor.

- Temperature

Elevated temperatures can stress benthic organisms and provide sub-optimal conditions for their survival. Lodge Creek is classified as a Class III Non-tidal Piedmont and Coastal stream with a maximum temperature standard of 32°C. No violations of the temperature standard were recorded during field measurements taken concurrently with the biological samples. Therefore, no evidence supported temperature as a stressor, and it was eliminated.

3.3.2. Possible Stressors

- Nutrients

Excessive nutrient inputs can lead to excessive algal growth, eutrophication, and low dissolved oxygen concentrations which may adversely affect the survival of benthic macroinvertebrates. In particular, dissolved oxygen levels may become low during overnight hours due to plant respiration. The benthic samples from Lodge Creek can be characterized as being dominated by either chironomidae or hydropsychidae – organisms possibly associated with excessive nutrients - and as having low diversity, with the two dominant organisms comprising more than 70% of each sample. Consistent poor ratings are also given for riparian vegetation in the habitat assessment. However, since all DO measurements have been in compliance with the water quality standard, nutrients have only been considered to be a possible stressor.

- Organic Matter

Excessive organic matter can lead to low in-stream dissolved oxygen concentrations, which may adversely affect the survival and growth of benthic macroinvertebrates. Potential sources of organic matter in Lodge Creek include sewer system overflows and runoff from impervious areas. Organic enrichment is supported by the moderate to high values of the Modified Family Biotic Index (MFBI), the abundance of hydropsychidae and simuliidae – typical of organic-enriched sites, and the reports of frequent sewer system overflows. On the other hand, the DO levels recorded at the time of biological sampling were all above the minimum water quality standard. The % of filterer-collectors was highly variable from sample to sample, indicating availability of organic inputs in each of the Spring samples. Therefore, organic matter is considered to be a possible stressor, but not the most likely one causing the original impairment.

- Toxics

Toxic substances by definition are not well tolerated by living organisms. The presence of toxics as a stressor in a watershed may be supported by very low numbers of all types of organisms, low organism diversity, violations of freshwater aquatic life criteria or consensus-based PECs for metals or inorganic compounds, by low percentages of the shredder population, reports of fish kills, or by the presence of available sources. There are no current PS dischargers in Lodge Creek, although University of Virginia facilities are found in upstream areas of the watershed. There are abundant organisms present. Since there were no suspected sources of metals in the watershed, no sediment samples had been collected and analyzed. Because of the unknown constituents in sewer overflows, toxics are considered to be a possible stressor, but with a fairly remote likelihood.

3.3.3. Most Probable Stressors

The two most probable stressors to the benthic community are considered to be hydrologic modifications and sediment based on the following summary of available evidence.

- Hydrologic Modifications

Hydrologic modifications can cause shifts in the supply of water, sediment, food supply, habitat, and pollutants from one part of the watershed to another, thereby causing changes in the types of biological communities that can be supported by the changed environment. The Lodge Creek watershed contains a large amount of urban impervious areas, comprising 19.6% of the watershed, and frequent sewer system overflows. Although these modifications are considered as “pollution” and not “pollutants” covered by the TMDL legislation, hydrologic modifications are considered a most probable stressor as they modify hydrologic regimes, which are likely to increase channel erosion and sediment loads downstream.

- Sediment

Excessive sedimentation can impair benthic communities through loss of habitat. Excess sediment can fill the pores in gravel and cobble substrate, eliminating macroinvertebrate habitat. Potential sources of sediment include residential runoff, forest harvesting operations, construction sites, and in-stream disturbances.

Sediment loads may arise from barren areas and construction sites, but channel erosion from unstable banks and washoff from impervious areas are the most obvious contributors. Supportive evidence includes consistent ratings of “poor” for riparian vegetation in Lodge Creek; observations of many sites with insufficient buffer and active erosion areas in the 2005 City of Charlottesville’s Stream Corridor Assessment; and citizen-narrated video footage on YouTube that shows the contribution from unstable stream banks in the area during storm runoff. Sediment is considered to be a most probable stressor in Lodge Creek because of its poor riparian vegetation, the inventory of areas with insufficient buffer and active erosion, and visual evidence of bank instability.

3.4. Analysis of Candidate Stressors for Meadow Creek

The suspected source of the benthic impairment in Meadow Creek was listed as Non-Point Source in the 2010 List of Impaired Waters. The DEQ ambient and biological monitoring station along this stream segment is conducted at 2-MWC000.60. In order to further discriminate sources, a stressor analysis was performed on all available data. The stressor may be something that either directly affected the benthic community or indirectly affected its habitat. Virginia SCI ratings suggest that the benthic community has been severely impaired throughout the period from 2004 to 2009.

A list of candidate stressors was developed for Meadow Creek and evaluated to determine the pollutant(s) responsible for the benthic impairment. A potential stressor checklist was used to evaluate known relationships or conditions that may show associations between potential stressors and changes in the benthic community. Available evidence was then summarized for each potential stressor. Depending on the strength of available evidence, the potential stressors were either “eliminated”, considered as “possible” stressors, or recommended as the “most probable” stressor(s). Candidate stressors included ammonia, hydrologic modifications, metals, nutrients, organic matter, PAHs, pH, sediment, TDS/conductivity/sulfates, temperature, and toxics. The evaluation of each candidate stressor is discussed in the following sections.

3.4.1. Eliminated Stressors

- Ammonia

High values of ammonia are toxic to many fish species and may impact the benthic community as well. Most of the values recorded at the DEQ ambient monitoring station were at or below the minimum detection limit (MDL) of 0.04 mg/L and, therefore, ammonia was eliminated from further consideration as a stressor for Meadow Creek.

- Metals

Increased metals concentrations lead to low diversity and low total abundance of benthic organisms, with specific reduced abundance of metal-sensitive mayflies and increased abundance of metal-tolerant chironomids (Clement, 1994). Total organism abundance was moderate with hydropsychidae and chironomidae dominating other organisms. Although these may be associated with elevated metals, no water column or sediment concentrations were found that exceeded their respective public water supply standards or sediment PECs. Therefore, metals were eliminated from further consideration as a possible stressor.

- pH

Benthic macroinvertebrates require a specific pH range of 6.0 to 9.0 to live and grow. Changes in pH may adversely affect the survival of benthic macroinvertebrates. Treated wastewater, mining discharge and urban runoff can potentially alter in-stream levels of pH. No violations of the minimum or maximum pH standard were reported at the DEQ station on the impaired segment. Therefore, pH was eliminated from further consideration as a stressor.

- TDS/Conductivity/Sulfates

Total dissolved solids (TDS) are the inorganic salts, organic matter and other dissolved materials in water. Elevated levels of TDS cause osmotic stress and alter the osmoregulatory functions of organisms (McCulloch et al., 1993). The average TDS and conductivity measurements reported in DEQ monitoring data for Meadow Creek watershed were all considerably lower than for the reference watershed screening values of 500 mg/L and 500 µmhos/cm, respectively. Therefore, this suite of stressors was eliminated from further consideration as a possible stressor.

- Temperature

Elevated temperatures can stress benthic organisms and provide sub-optimal conditions for their survival. Meadow Creek is classified as a Class III Non-tidal Piedmont and Coastal stream with a maximum temperature standard of 32°C. No violations of the temperature standard were recorded by DEQ ambient monitoring or by monitoring during collection of the biological samples. Therefore, no evidence supported temperature as a stressor, and it was eliminated.

3.4.2. Possible Stressors

- Nutrients

Excessive nutrient inputs can lead to excessive algal growth, eutrophication, and low dissolved oxygen concentrations which may adversely affect the survival of benthic macroinvertebrates. In particular, dissolved oxygen levels may become low during overnight hours due to plant respiration.

The benthic community in Meadow Creek can be characterized as being dominated by chironomidae and hydropsychidae – organisms associated with excessive nutrients - and as having low diversity, with the two dominant organisms comprising more than 70% of each sample. Dissolved N and P concentrations are above eutrophication sufficiency levels in lakes, although no samples have exceeded DEQ's "threatened water" TP levels. However, since all DO measurements are in compliance with the minimum water quality standard, nutrients are only considered to be a possible stressor.

- Organic Matter

Excessive organic matter can lead to low in-stream dissolved oxygen concentrations, which may adversely affect the survival and growth of benthic macroinvertebrates. The primary potential source of organic matter in Meadow Creek is runoff from impervious areas. Organic enrichment is supported by the moderate to high values of the

Modified Family Biotic Index (MFBI) in 4 of 5 samples and the low SC/FC ratios (all < 0.5). On the other hand, there have been no monitored DO standard violations; no excessive diurnal DO fluctuations; and the low percentages of filterer-collector organisms do not support organic matter as being excessive in the middle three samples (October 2004 – October 2008), though the first sample in April 2004 and the last sample in March 2009 had large percentages. Therefore, organic matter is considered to be a possible stressor, but not the most likely one causing the original impairment.

- PAHs

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous contaminants derived from fossil fuels and their incomplete combustion. Some are highly potent carcinogens. PAHs generally occur as mixtures of tens to hundreds of related hydrocarbon compounds. While individual PAHs can cause toxicity at certain levels, cumulative effects from multiple compounds at lower levels are also suspected of causing toxicity. PAHs have been detected in the seven samples taken at a combination of 4 different sites on 3 different sampling dates. Of these, only one out of 9 compounds with established PECs exceeded its PEC in one sample, indicative of levels that could cause toxicity; and two of the samples had a Mean-PEC Quotient that would indicate the possibility of cumulative toxicity. This station is, however, just downstream from its confluence with Schenks Branch, which appears to be the source of high PAHs in the watershed. Therefore, because these substances have been detected at potentially toxic levels, they are listed as possible stressors. Although the possibility of PAH toxicity is a concern, PAHs are not listed as a probable cause of the aquatic life use impairment, because other pollutants are considered to more directly impact the abundance and diversity of the benthic community .

- Toxics

Toxic substances by definition are not well tolerated by living organisms. The presence of toxics as a stressor in a watershed may be supported by very low numbers of any type of organisms, low organism diversity, violations of freshwater aquatic life criteria or consensus-based PECs for metals or inorganic compounds, by low percentages of the shredder population, reports of fish kills, or by the presence of available sources. Since there are multiple historical and current oil processing and refining facilities in the watershed, many reports of petroleum releases, an violation of one PAH PEC, and a consistently low percentage of shredders, toxicity is a possibility. However, there are abundant organisms present and there have been no violations of sediment-related PECs or in-stream Aquatic Life Use criteria for metals. Because of the presence of some of these sources, toxics are considered to be a possible stressor, but not the most likely one.

3.4.3. Most Probable Stressors

The two most probable stressors to the benthic community are considered to be hydrologic modifications and sediment based on the following summary of available evidence.

- Hydrologic Modifications

Hydrologic modifications can cause shifts in the supply of water, sediment, food supply, habitat, and pollutants from one part of the watershed to another, thereby causing changes in the types of biological communities that can be supported by the changed environment. Meadow Creek watershed contains a large amount of urban impervious area (23%) and there is a considerable amount of channelization in the Schenks Branch tributary. Although these modifications are considered as “pollution” and not “pollutants” covered by the TMDL legislation, hydrologic modifications are considered a most probable stressor as they modify hydrologic regimes, which are likely to increase channel erosion and sediment loads downstream.

- Sediment

Excessive sedimentation can impair benthic communities through loss of habitat. Excess sediment can fill the pores in gravel and cobble substrate, eliminating macroinvertebrate habitat. Potential sources of sediment include residential runoff, forest harvesting operations, construction sites, and in-stream disturbances.

Sediment loads in the Meadow Creek watershed may arise from barren areas and construction sites, but channel erosion from unstable banks and washoff from impervious areas are the most obvious contributors. Sediment is supported as a stressor for this impairment through the poor bank stability habitat metric, which is directly related to sediment. Ambient TSS concentrations are low, but no samples were taken during storm events when higher TSS concentrations would be expected. The City of Charlottesville's Stream Corridor Assessment in 2005 also noted many riparian sites along Meadow Creek and tributaries with insufficient buffer and active erosion. Sediment is considered a most probable stressor in Meadow Creek because of the poor habitat metric related to sediment, and the inventory of areas with insufficient buffer and active erosion.

3.5. Analysis of Candidate Stressors for Schenks Branch

The suspected source of the benthic impairment in Schenks Branch was listed as Non-Point Source in the 2010 List of Impaired Waters. The primary DEQ monitoring stations along this stream segment and an unnamed tributary are 2-SNK000.88 and 2-XSN000.08, which are used for both ambient and biological monitoring. In order to further discriminate sources, a stressor analysis was performed on all available data. The stressor may be something that either directly affected the benthic community or indirectly affected its habitat. Virginia SCI ratings suggest that the benthic community has been severely impaired throughout the period from 2005 to 2009.

A list of candidate stressors was developed for Schenks Branch and evaluated to determine the pollutant(s) responsible for the benthic impairment. A potential stressor checklist was used to evaluate known relationships or conditions that may show associations between potential stressors and changes in the benthic community. Available evidence was then summarized for each potential stressor. Depending on the strength of available evidence, the potential stressors were either “eliminated”, considered as “possible” stressors, or recommended as the “most probable” stressor(s). Candidate stressors included ammonia, hydrologic modifications, metals, nutrients, organic matter, PAHs, pH, sediment, TDS/conductivity/sulfates, temperature, and toxics. The evaluation of each candidate stressor is discussed in the following sections.

3.5.1. Eliminated Stressors

- Ammonia

High values of ammonia are toxic to many fish species and may impact the benthic community as well. Although ammonia was not monitored in Schenks Branch, most of the values recorded at the downstream DEQ ambient monitoring station on Meadow Creek were at or below the minimum detection limit (MDL) of 0.04 mg/L and, therefore, it was eliminated from further consideration as a stressor for Schenks Branch.

- **Metals**

Increased metals concentrations lead to low diversity and low total abundance of benthic organisms, with specific reduced abundance of metal-sensitive mayflies and increased abundance of metal-tolerant chironomids (Clement, 1994). Total organism abundance was moderate with chironomidae and naididae dominating other organisms. Although these may be associated with elevated metals, no sediment concentrations were reported that exceeded their sediment PECs in a 2008 sample. Therefore, metals were eliminated from further consideration as a possible stressor.

- **pH**

Benthic macroinvertebrates require a specific pH range of 6.0 to 9.0 to live and grow. Changes in pH may adversely affect the survival of benthic macroinvertebrates. Treated wastewater, mining discharge and urban runoff can potentially alter in-stream levels of pH. No violations of the minimum or maximum pH standard were reported at any of the DEQ stations on the impaired segment. Therefore, pH was eliminated from further consideration as a stressor.

- **TDS/Conductivity/Sulfates**

Total dissolved solids (TDS) are the inorganic salts, organic matter and other dissolved materials in water. Elevated levels of TDS cause osmotic stress and alter the osmoregulatory functions of organisms (McCulloch et al., 1993). The average conductivity measurements reported in DEQ monitoring data for Schenks Branch watershed were all considerably lower than the reference watershed screening values of 500 µmhos/cm, although they were much higher than in nearby Moores Creek and Meadow Creek. Therefore, this suite of stressors was eliminated from further consideration as a possible stressor.

- Temperature

Elevated temperatures can stress benthic organisms and provide sub-optimal conditions for their survival. Schenks Branch is classified as a Class III Non-tidal Piedmont and Coastal stream with a maximum temperature standard of 32°C. No violations of the temperature standard were recorded by DEQ ambient monitoring or by monitoring during collection of the biological samples. Although low riparian vegetation habitat metric scores were observed, they did not correspond with elevated temperature levels. Therefore, no evidence supported temperature as a stressor, and it was eliminated.

3.5.2. Possible Stressors

- Nutrients

Excessive nutrient inputs can lead to excessive algal growth, eutrophication, and low dissolved oxygen concentrations which may adversely affect the survival of benthic macroinvertebrates. In particular, dissolved oxygen levels may become low during overnight hours due to plant respiration.

The benthic community in Schenks Branch can be characterized as being partially dominated by chironomidae – an organism associated with excessive nutrients - and having a low diversity, with the two dominant organisms comprising more than 70% of each sample. Elevated TN concentrations were observed in both samples taken from Schenks Branch and an unnamed tributary. On the other hand, no reported TP concentrations have exceeded “threatened” levels and no DO standard violations were observed in either DEQ ambient field monitoring or in a diurnal DO study. Therefore, nutrients have only been considered to be a possible stressor.

- Organic Matter

Excessive organic matter can lead to low in-stream dissolved oxygen concentrations, which may adversely affect the survival and growth of benthic macroinvertebrates. The major potential source of organic matter in Schenks Branch is impervious area runoff. Organic enrichment is supported by the moderate to high values of the Modified Family Biotic Index (MFBI), the high percentage of filterer-collectors (all > 73.9%), and the large number of naididae organisms. On the other hand, there have been no monitored DO standard violations and no excessive diurnal DO fluctuations to support organic matter as being excessive. Therefore, organic matter is considered as only a possible stressor of the original impairment.

- PAHs

Introduction: Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous trace contaminants derived from fossil fuels and their incomplete combustion. Some are highly potent carcinogens. PAHs generally occur as mixtures of tens to hundreds of related hydrocarbon compounds. While individual PAHs can cause toxicity at certain levels, cumulative effects from multiple compounds at lower levels are also suspected of causing toxicity. While water quality standards exist for certain PAH compounds for Public Water Supplies and Other Surface Waters in Virginia, no water column samples were analyzed in this watershed for comparison against these standards. As is more usual, sediment samples are periodically analyzed and compared with consensus-based probable effects concentrations (PECs), which are levels that could possibly cause toxicity. Nine of these PAH compounds are considered EPA Priority Pollutants for which PECs have been established.

Measured Values: PAHs were detected in all 14 samples taken from Schenks Branch and its tributaries in 2009 and 2010. The highest values originated from a culverted headwater section of an unnamed tributary to Schenks Branch, and then appear to have affected downstream measurements in Schenks Branch and Meadow Creek.

Interpretation of Measured Values: About half of the PAH congeners with established PECs exceeded their PECs in 5 of the samples in the unnamed tributary. Likewise in Table 2-12, these same 5 samples had Mean-PEC Quotients > 0.5 (indicative of the possibility of cumulative toxicity) at levels deemed potentially toxic and appeared to influence 2 samples in Schenks Branch and 2 samples in Meadow Creek with Mean-PEC Quotients greater than 0.5. Another measure of cumulative toxicity is the Hazard Index (Neff et al., 2005), but since this measure is based on water column measurements and no water column samples were analyzed, this measure could not be evaluated.

PAHs have been shown to directly affect mortality in sensitive aquatic species, according to a review by Ingersoll et al. (2001). PAHs, however, have become fairly common and have been detected in many places around Virginia that have sampled and analyzed for PAHs, as is shown in Table 3-1. This table represents a selection from all of the Probability Monitoring (ProbMon) sites that DEQ sampled for PAHs during 2005 and 2006. This selection includes those stations with the largest number of PAHs detected per sample. These samples were then matched with one or more benthic sample Virginia Stream Condition Indices (VSCI) that were evaluated during approximately the same period (October 2003 through May 2006), though from different sample dates. Although very few PAHs exceeded their respective PECs and no sample had a Mean-PEC Quotient greater than 0.5, many stations with healthy benthic communities (VSCI > 60) reported the presence of many different PAH compounds. Since both impaired and non-impaired stations reported the presence of PAHs, their presence alone is not sufficient proof of cause and effect.

Table 3-1. VSCI Scores from ProbMon Sites in Virginia with PAH Measurements (Shaded VSCI scores greater than 60 indicate non-impairment)

DEQ Station ID	Sampling Date	Stream Name	Most Recent VSCI	No. of VSCI samples	No. of PAH parameters /sample	No. of PAH parameters > MDL	No. of PAH parameters > PEC (max = 9)	Mean-PEC Quotient
6CNFH067.13	04/05/06	North Fork Holston River	65.01	2	32	28	0	0.143
6BLUR000.60	04/06/06	Laurel Branch	62.72	2	32	22	0	0.051
6ASLV000.85	04/04/06	Sullivan Branch	51.00	2	32	17	0	0.148
6CNFH014.72	03/27/06	North Fork Holston River	53.30	1	32	16	0	0.026
6ARPC002.45	03/30/05	Russell Prater Creek	45.71	2	17	16	0	0.146
6APNR034.58	03/31/05	POUND RIVER	42.34	3	17	15	0	0.096
6CNFH033.45	04/06/05	North Fork Holston River	#N/A	0	17	14	0	0.076
9-TOM006.92	05/02/06	Toms Creek	60.77	3	32	13	0	0.040
6BPOW123.64	04/28/05	Powell River	#N/A	0	17	13	1	0.350
2-RGR001.11	04/13/06	Roaring Run	71.83	5	32	12	0	0.025
2-PLP002.24	03/29/06	Phelps Branch	62.25	2	32	12	0	0.039
9-NEW056.13	05/15/06	New River	#N/A	0	32	11	0	0.074
5AXGI001.79	04/25/06	Unnamed Tributary to Blackwater	38.34	4	32	11	0	0.060
9-LFK005.39	04/07/05	Laurel Creek	70.19	2	17	11	0	0.018
1APAR001.78	05/12/05	Parish Run	#N/A	0	17	10	0	0.031
2-CWP006.87	05/12/05	Cowpasture River	81.90	2	17	10	0	0.030
2AXQT000.66	05/10/06	Johns Run, UT (JHN)	77.33	1	32	10	0	0.054
4AXMU001.98	05/23/05	Mill Creek, UT (MCA)	77.46	1	17	10	0	0.047
6APNR034.58	05/01/06	POUND RIVER	42.34	3	32	10	0	0.024
3-MTN018.83	05/23/06	Mountain Run	25.42	2	32	9	0	0.026
2-XYC000.31	04/13/06	UT TO CHICKAHOMINY RIVER	38.96	2	32	9	0	0.012
3-XFB001.00	03/30/06	Unnamed trib to Massaponax Cree	48.44	2	32	8	0	0.025
6BPOW170.76	03/29/05	Powell River	#N/A	0	17	8	1	0.332

While PAHs appear to affect the abundance of the most sensitive benthic species, the causative link between PAHs in sediment and overall benthic community health is still debatable.

Possible Sources of PAHs in the watersheds: As explained in the introduction to this possible stressor, many different sources of PAHs are present in urban watersheds. A few of the common sources are listed in Table 3-2 as excerpted from Neff et al. (2005). In addition to these general sources, spills of petroleum products (one fairly significant) had been reported in two separate incidences in Meadow Creek and Schenks Branch (Table 2-16) the summer before the first samples were taken in March 2009. Two dischargers in these watersheds have VPDES permits that allow total petroleum hydrocarbons (TPH) and that have reported average annual TPH concentrations many times greater than the water quality standards for total PAHs. While TPH includes many other types of hydrocarbons, it may also include PAHs, though the proportion in these discharges is unknown. There have also been multiple oil processing and refining facilities in the Schenks Branch watershed for many years, and the significant amount of impervious area in these watersheds no doubt receives large amounts of coal-tar based sealants, which have recently been identified as a major source of PAHs in some urban settings (Van Metre and Mahler, 2010; USGS, 2009).

Table 3-2. Common Types of PAHs from Pyrogenic and Petrogenic Sources as indicated by differing ranges of PAH isomer ratios, phenanthrene to anthracene (PH/AN) and fluoranthene to pyrene (FL/PY) (Neff et al., 2005)

Source	**PH/AN**	**FL/PY**
Primarily pyrogenic sources		
Coke oven emissions	1.27 - 3.57	0.76 - 1.31
Iron/steel plant (soot)	0.24	0.62
Iron/steel plant (flue gas)	0.06	1.43
Wood-burning emissions	6.41	1.26
Auto exhaust soot (gasoline)	1.79	0.9
Diesel engine soot	0.06	1.26
Diesel exhaust particles	1.3 - 7.8	0.25 - 1.38
Highway dust	4.7	1.4
Urban runoff	0.56 - 1.47	0.23 - 1.07
Creosote	0.11 - 4.01	1.52 - 1.70
Coal tar	3.11	1.29
Coke oven emissions	0.24	1.49
Creosote-contaminated sediment	0.34	1.59
Urban sediment	0.22	0.79
Primarily petrogenic sources		
60 crude oils (mean)	52	0.25
Australian crude oil	>370[a]	0.78
Italian crude oil	>232[a]	0.08
Alaska crude oil	>262[a]	0.2
Diesel fuel (No. 2 fuel oil)	>800[a]	0.38
No. 4 fuel oil	11.8	0.16
Bunker C residual fuel oil	14.8	0.14
Road paving asphalt	20	<0.11[a]
West Virginia coal (2 samples)	11.2, 27.9	0.95, 1.03

[a] Anthracene or fluoranthene concentration was below the detection limit.

Reasons for Not Naming PAH as a Most Probable Stressor. As substances with carcinogenic properties, PAHs are a concern in the watershed, but they are not the most likely cause of the present benthic impairment. Since sampling for PAHs has occurred only recently, it is not known whether the high values may be attributed to specific incidences, e.g. the cited spills, or to more long-term chronic conditions. Low values of the VSCI have been monitored since 2005, so if the high PAHs resulted from the recent incidences, it would be obvious that other sources have affected the health of the benthic community. As it stands, it is not possible to definitively describe the onset of high PAH measurements or its relationship with benthic health. What we do know is that PAHs adsorb to sediment with low partitioning to the water column and that baseflow is minimal in the unnamed tributary to Schenks Branch. Also, since the entire flow to the unnamed tributary at the monitoring point flows through a culvert, all contributions are likely from spills, stormwater runoff, or illicit discharges through the storm drains, with storage in the bottom sediments in between storms. The amounts appear to be small overall, and since sediment is transported by stormflow, this loading could be minimized by installation of a constructed wetland at the outlet of the culvert to trap and allow biodegradation of the contaminants. So, while the PAHs are a possible stressor and definitely a concern that can be addressed in the implementation plan, they are not considered the most probable cause of the impairment. However, control of one of the most probable causes (sediment) discussed in the next section may also indirectly reduce PAH loading.

- Toxics

Toxic substances by definition are not well tolerated by living organisms. The presence of toxics as a stressor in a watershed may be supported by very low numbers of any type of organisms, low organism diversity, violations of freshwater aquatic life criteria or consensus-based PECs for metals or inorganic compounds, by low percentages of the shredder population, reports of fish kills, or by the presence of available sources. Since there are multiple historical and current oil processing and refining facilities in the watershed, many reports of petroleum releases, several violations of PAH PECs, one recent violation of the chlordane PEC, and a consistently low percentage of shredders, toxicity is a possibility. However, there are abundant organisms present, small fish have been observed, and there have been no violations of sediment-related PECs or in-stream Aquatic Life Use criteria for metals. Because of the presence of some of these sources, toxics are considered to be a possible stressor, but not the most likely one.

3.5.3. Most Probable Stressors

The two most probable stressors to the benthic community are considered to be hydrologic modifications and sediment based on the following summary of available evidence.

- Hydrologic Modifications

Hydrologic modifications can cause shifts in the supply of water, sediment, food supply, habitat, and pollutants from one part of the watershed to another, thereby causing changes in the types of biological communities that can be supported by the changed environment. Schenks Branch watershed contains a large amount of urban impervious area and some of the headwater tributaries are enclosed in culverts. Although these modifications are considered as “pollution” and not “pollutants” covered by the TMDL legislation, hydrologic modifications are considered a most probable stressor, as they change the hydrologic regime in a watershed, which leads to increases in channel erosion and sediment loads downstream.

- Sediment

Excessive sedimentation can impair benthic communities through loss of habitat. Excess sediment can fill the pores in gravel and cobble substrate, eliminating macroinvertebrate habitat. Potential sources of sediment include residential runoff, forest harvesting operations, construction sites, and in-stream disturbances.

Sediment loads may arise from barren areas and construction sites, but channel erosion from unstable banks and washoff from impervious areas are the most obvious contributors. Sediment is supported as a stressor for this impairment through the poor habitat metrics related to sediment including riparian vegetation and channel alteration. The City of Charlottesville's Stream Corridor Assessment in 2005 also noted many riparian sites along Schenks Branch and its unnamed tributary with insufficient buffer and active erosion. Even though the relative bed stability (RBS) metrics showed only moderate impacts from anthropogenic sources, the %fines metric value, which impacts interstitial habitat niches in the channel bottom, was similar to those on the main stem of the Rivanna River, where the %fines metric was used as partial justification for naming sediment as the most probable stressor for its benthic impairment. Sediment is considered a most probable stressor in Schenks Branch because of the poor habitat metrics related to sediment, and the inventory of areas with insufficient buffer and active erosion.

3.6. Summary

The Moores Creek (VAV-H28R_MSC01A00) stream segment is severely impaired for its aquatic life use, with individual VSCI sample scores of 28.3 and 34.9, where a score of 60 or above represents a non-impaired condition (scale: 0 – 100). The Moores Creek watershed is impacted by a variety of agricultural and urban land uses. Sediment was selected as the most probable stressor based on the repeated poor scores for sediment metrics in the habitat assessments and the observations of insufficient buffer, erosion and bank instability at many locations in the watershed.

The Lodge Creek (VAV-H28R_XRC01A04) stream segment is severely impaired for its aquatic life use, with individual VSCI sample scores ranging from 20.6 to 37.8, where a score of 60 or above represents a non-impaired condition (scale: 0 – 100). The Lodge Creek watershed is impacted by urban land uses. Hydrologic modifications and sediment were selected as the most probable stressors based on the high percent imperviousness, repeated poor scores for riparian vegetation, and the observations of insufficient buffer, erosion, and bank instability at many locations along the stream.

The Meadow Creek (VAV-H28R_MWC01A00) stream segment is severely impaired for its aquatic life use, with individual VSCI sample scores ranging from 16.7 to 37.4, where a score of 60 or above represents a non-impaired condition (scale: 0 – 100). The Meadow Creek watershed is impacted by urban land uses. Hydrologic modifications and sediment were selected as the most probable stressors based on the high percent of impervious area, repeated poor scores for sediment metrics in the habitat assessments, and the observations of insufficient buffer and active erosion sites at many locations in the watershed.

The Schenks Branch (VAV-H28R_SNK01A02) stream segment is severely impaired for its aquatic life use, with individual VSCI sample scores from both this segment and its unnamed tributary ranging from 16.8

to 29.0, where a score of 60 or above represents a non-impaired condition (scale: 0 – 100). The Schenks Branch watershed is impacted by urban land uses. Hydrologic modifications and sediment were selected as the most probable stressors based on the high percent of impervious area, repeated poor scores for sediment metrics in the habitat assessments, and the observations of insufficient buffer and active erosion sites in many riparian locations along the stream.

CHAPTER 4: SETTING A REFERENCE SEDIMENT LOAD

4.1. Introduction

Since there is no water quality standard for sediment in Virginia, an alternate method is needed for establishing a reference endpoint that represents the “non-impaired” condition. Although elevated sediment concentrations can affect the ability of fish to breathe and see their predators in water, it is generally the total amount, or the load, that is responsible for the stress to aquatic organisms, by limiting the available habitat on the bottom of stream channels. Therefore, the reference endpoint will be developed as a long-term average annual sediment load.

These watersheds are also subject to the provisions of the Chesapeake Bay TMDL (USEPA, 2010b) for a downstream tidal segment which will include a sediment load component. In an attempt to maintain a degree of consistency between development of these local TMDLs and the downstream Chesapeake Bay TMDL, load output from various scenarios run with the Phase 5.3.2 Chesapeake Bay Watershed Model were used to develop baseline and TMDL sediment loads to address the biological impairment in these two watersheds using the Disaggregate Method (Yagow et al., 2012a). The 2009 Progress Run will be used for the baseline load calculations, while the final Virginia Watershed Implementation Plan (WIP) Run used for the Bay TMDL, and updated on June 30, 2011, will be used to calculate reference loads.

This approach is based on the assumption that reduction of the sediment loads in the impaired watershed to a proportional level of the loads called for in the Chesapeake Bay TMDL for a downstream tidal segment will improve water and habitat quality and result in elimination of the local benthic impairment. Although sediment is used as a surrogate for benthic health in the development of these TMDLs, attainment of a healthy benthic community will ultimately be based on biological monitoring of the benthic macroinvertebrate community, in accordance with established DEQ protocols. If a future review should find that the reductions called for in these TMDLs based on current modeling are found to be insufficiently protective of local water quality, then revision(s) will be made as necessary to provide reasonable assurance that water quality goals will be achieved.

CHAPTER 5: MODELING PROCESS FOR DEVELOPMENT OF THE SEDIMENT TMDLS

A key component in developing a TMDL is establishing the relationship between pollutant loadings (both point and nonpoint) and in-stream water quality conditions. Once this relationship is developed, management options for reducing pollutant loadings to streams can be assessed. In developing a TMDL, it is critical to understand the processes that affect the fate and transport of the pollutants and cause the impairment of the waterbody of concern. Pollutant transport to water bodies is evaluated using a variety of tools, including monitoring, geographic information systems (GIS), and computer simulation models. In the development of the sediment TMDLs for the Moores Creek, Lodge Creek, Meadow Creek, and Schenks Branch watersheds, the relationship between sediment sources and sediment loading to the stream was defined by local assessments of land uses and areas, and of non-land based loads, together with existing model output from the Phase 5.3.2 of the CBWM. The modeling process and load calculation procedures using the disaggregate method are discussed in this chapter.

5.1. Overview of Load Calculation Procedure

For these TMDLs, sediment loads were calculated from a local inventory of land uses and the unit-area loads (UALs) for corresponding land uses from the Chesapeake Bay Watershed Model (CBWM) as available through the Virginia Assessment Scenario Tool (VAST; ICPRB, 2011). Land-river segment loads and areas are available from the "Data by Land River Segment" link at the bottom of the Compare Scenario page. Baseline loads were calculated using UALs from the 2009 Progress scenario applied to 2010 Landuse acreages, while Reference loads were calculated using UALs from the WIP1-VA scenario based on the December 2010 Chesapeake Bay TMDL and later revised for the Phase 5.3.2 simulation output reported on June 30, 2011, and further revised on November 7,

2011. English units of acres and tons are used to report areas and simulated sediment loads, respectively, in this report.

5.2. Accounting for Critical Conditions and Seasonal Variations

The modeling period for these TMDLs was the same as that used in modeling loads for the Chesapeake Bay TMDL, namely 1984 – 2005. This 22-year period captures the wide variability in annual and seasonal rainfall that result in sediment detachment and transport in these watersheds.

5.2.1. Critical Conditions

The CBWM is a continuous simulation model that uses an hourly time step. The period of rainfall selected for modeling was chosen as a multi-year period that was representative of typical weather conditions for the area, and included “dry”, “normal”, and “wet” years. The model, therefore, incorporated the variable inputs needed to represent critical conditions during low flow – generally associated with point source loads and in-stream disturbances – and critical conditions during high flow – generally associated with nonpoint source loads.

5.2.2. Seasonal Variability

The CBWM model, on which the unit-area loads in this analysis are based, considered seasonal variation through a number of mechanisms. The use of hourly time steps, seasonally variable rainfall inputs, seasonal erodibility coefficients, and seasonal representation of agricultural tillage, harvesting, and management actions all contributed to the incorporation of seasonal variability as it manifested itself variably on different landuses represented in the model.

5.3. Local Area Representation

The CBWM represents land area through an assortment of 1,185 river segments whose boundaries are further intersected by jurisdictional boundaries, and in some cases, boundaries related to different weather gauges. The resulting land-river segments are the smallest geographical unit and the unit around which model inputs are evaluated, and from which model outputs are obtained. There is one river segment (JL4_6520_6710) which encompasses the four watersheds in this study, and two land-river segments (A51003JL4_6520_6710 and A51540JL4_6520_6710) defined by the Albemarle County/City of Charlottesville boundary line within the river segment. For this report, these two land-river segments will be referred to as the Albemarle (003) portion and the Charlottesville (540) portion of each watershed. A summary of watershed areas within each land-river segment is given in Table 5-1.

Table 5-1. Area Distribution between Land-River Segments in the Four Watersheds (acres)

Watershed	Albemarle 003	Charlottesville 540	Total Area (acres)
Lodge Creek	106.2	365.3	471.4
Moores Creek*	19,963.4	1,897.1	21,860.5
Schenks Branch	14.1	1,394.0	1,408.1
Meadow Creek*	2,433.1	1,977.5	4,410.6

* Moores Creek excludes Lodge Creek; Meadow Creek excludes Schenks Branch.

5.4. Local Land Use Representation

5.4.1. Existing or Baseline Scenario

In order to represent these watersheds with local land use for the calculation of corresponding sediment loads from Phase 5.3.2 of the CBWM, it is first necessary to relate available land use categories with the 35 land use/source categories used in that model. Five of the categories are related to point sources and will be discussed in the next section, “Non-Land Based Loads”. Additionally, three categories of “extractive”, three categories of combined storm sewer (CSS), “CAFO”, and “nursery” categories were not identified locally and, therefore, were not included in the distribution. The remaining 23 land-based categories are shown in Table 5-2. These land-based categories were created from a combination of GIS spatial data, such as National Land Cover Dataset (NLCD) imagery, and statistical data, such as the USDA’s Agricultural Census Statistics data by county. Many of the agricultural categories are combinations of land uses and land management practices. In order to provide a measure of consistency with the construction of these categories for the Bay model, these 23 land uses were combined into agricultural groups and urban/residential categories that could more easily be matched with local land use assessments. Within each land-river segment, the distribution of land use categories within each group can then be used to sub-divide the local land use group areas into the sub-categories corresponding with the full spectrum of land uses used in the Bay model. In Table 5-2, the groups from the Bay model, and the distributions within each group, are shown for the Albemarle 003 land-river segment, as an example.

Table 5-2. Chesapeake Bay Watershed Model (Phase 5.3.2) Land Uses, Groups, and Distributions within each Group for an Example Land-River Segment

Landuse Group	P532 Landuse Code	P532 Landuse Name	Distribution within each Group
Conventional Tillage - no manure	hom	high-till without manure	95.9%
	nho	high-till without manure NM	4.1%
All Other Row Crops	hwm	high-till with manure	2.0%
	nhi	high-till with manure NM	49.3%
	lwm	low-till with manure	2.1%
	nlo	low-till with manure NM	0.0%
Hay	hyw	hay with nutrients	72.3%
	nhy	hay with nutrients NM	3.1%
	alf	alfalfa	2.1%
	nal	alfalfa NM	0.1%
	hyo	hay without nutrients	22.5%
Pasture	pas	pasture	93.3%
	npa	pasture NM	4.0%
	trp	pasture corridor	2.7%
	afo	animal feeding operations	0.0%
Forest	for	forest	99.0%
	hvf	harvested forest	1.0%
Impervious Urban	rid	regulated impervious developed	29.2%
	nid	nonregulated impervious developed	70.8%
Pervious Urban	rpd	regulated pervious developed	43.5%
	npd	nonregulated pervious developed	54.5%
	rcn	regulated construction	1.9%
Water	atdep	atmospheric deposition	100.0%

The next step was to multiply the percentages within each group by the local group areas to calculate the area of all applicable land use categories within each land-river segment portion of each watershed, as shown for the "Moores Creek -003" portion in Table 5-3. There were two exceptions to this procedure as used in these watersheds, one for the “afo – animal feeding operation” land use, and the second for the pervious urban category. The “afo” area calculation will be described later under “Non-Land Based Loads”, although the acreage calculated by this method is subtracted from the total “Pasture” group acreage. Although a capitalized “AFO” is the acronym typically used for Animal Feeding Operations, the lower case “afo” is used throughout this report to conform to its usage as a P532 landuse in the CBWM. The 2 urban pervious and 1 construction categories were combined and then distributed according to the land-river segment distributions shown in Table 5-3.

Table 5-3. Local Land Use Areas (acres) Calculated for “Moores Creek – 003” Watershed Portion

Landuse Group	P532 Landuse Code	P532 Landuse Name	Distribution within each Group	Group Area (acres)	Distributed Area (acres)
Conventional Tillage - no manure	hom	high-till without manure	95.9%	60.6	58.1
	nho	high-till without manure NM	4.1%		2.5
All Other Row Crops	hwm	high-till with manure	46.6%	10.3	4.8
	nhi	high-till with manure NM	2.0%		0.2
	lwm	low-till with manure	49.3%		5.1
	nlo	low-till with manure NM	2.1%		0.2
Hay	hyw	hay with nutrients	72.3%	781.5	564.7
	nhy	hay with nutrients NM	3.1%		24.1
	alf	alfalfa	2.1%		16.4
	nal	alfalfa NM	0.1%		0.7
	hyo	hay without nutrients	22.5%		175.6
Pasture	pas	pasture	93.3%	207.5	189.5
	npa	pasture NM	4.0%		8.1
	trp	pasture corridor	2.7%		5.5
	afo	animal feeding operations	0.0%		4.4
Forest	for	forest	99.0%	13,081.7	12,951.2
	hvf	harvested forest	1.0%		130.6
Impervious Urban	rid	regulated impervious developed	29.2%	1,044.6	304.9
	nid	nonregulated impervious developed	70.8%		739.7
Pervious Urban	rpd	regulated pervious developed	43.5%	4,549.5	1,980.9
	npd	nonregulated pervious developed	54.5%		2,481.1
	rcn	regulated construction	1.9%		87.5
Water	atdep	atmospheric deposition	100.0%	227.7	227.7
Total				**19,963.4**	**19,963.4**

This same procedure was then repeated for both land-river segment portions in each watershed, with the resulting distribution of local land use areas translated into the Bay model categories, as shown in Table 5-4.

Table 5-4. Local Land Use Areas (acres) Distributed to Bay Model Categories - Baseline Scenario

	Lodge Creek		Moore's Creek*		Schenks Branch		Meadow Creek*	
P532 Landuse Name	**003 (acres)**	**540 (acres)**	**003 (acres)**	**540 (acres)**	**003 (acres)**	**540 (acres)**	**003 (acres)**	**540 (acres)**
high-till without manure	0.0	0.0	58.1	0.0	0.0	0.0	0.0	0.0
high-till without manure NM	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0
high-till with manure	0.0	0.0	4.8	0.0	0.0	0.0	3.4	0.0
high-till with manure NM	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.0
low-till with manure	0.0	0.0	5.1	0.0	0.0	0.0	3.6	0.0
low-till with manure NM	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.0
hay with nutrients	0.0	0.0	564.7	0.0	0.0	0.0	22.8	0.0
hay with nutrients NM	0.0	0.0	24.1	0.0	0.0	0.0	1.0	0.0
alfalfa	0.0	0.0	16.4	0.0	0.0	0.0	0.7	0.0
alfalfa NM	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0
hay without nutrients	0.0	0.0	175.6	0.0	0.0	0.0	7.1	0.0
pasture	0.0	0.0	189.5	0.0	0.0	0.0	11.7	0.0
pasture NM	0.0	0.0	8.1	0.0	0.0	0.0	0.5	0.0
pasture corridor	0.0	0.0	5.5	0.0	0.0	0.0	0.3	0.0
animal feeding operations	0.0	0.0	4.4	0.0	0.0	0.0	0.5	0.0
forest	6.7	43.2	12,951.2	160.6	0.6	52.6	422.5	232.5
harvested forest	0.1	0.4	130.6	1.6	0.0	0.5	4.3	2.3
regulated impervious developed	10.7	109.8	304.9	609.9	0.3	483.5	215.3	618.2
nonregulated impervious developed	26.0	0.1	739.7	0.6	0.7	0.5	522.2	0.6
regulated pervious developed	27.2	210.5	1,980.9	1,113.0	5.2	850.5	525.8	1,107.4
nonregulated pervious developed	34.1	0.2	2,481.1	1.0	6.5	0.8	658.6	1.0
regulated construction	1.2	1.1	87.5	5.7	0.2	4.4	23.2	5.7
atmospheric deposition	0.0	0.0	227.7	4.7	0.6	1.3	9.3	9.7
Total Area (acres)	**106.2**	**365.3**	**19,963.4**	**1,897.1**	**14.1**	**1,394.0**	**2,433.1**	**1,977.5**
Watershed Area Totals	**471.4**		**21,860.5**		**1,408.1**		**4,410.6**	

* Moore's Creek excludes Lodge Creek; Meadow Creek excludes Schenks Branch.

5.4.2. Reference Scenario

The land use distribution for the Reference scenario in Moores Creek, Lodge Creek, Meadow Creek, and Schenks Branch was based on Baseline scenario acreages and the changes in land use acreages between the Baseline and Reference model runs for each of the two land-river segment components in each watershed. The changes were quantified both as changes in the percentage of land use group acreages (Table 5-5) and in the percentage distributions of land use categories within each group (Table 5-6). Acreages for all land use categories that changed between scenarios were then scaled to preserve the total area within each watershed land-river portion, resulting in the final distribution of land use category acreages shown in Table 5-7.

Table 5-5. Percent Change in Group Acreage between Baseline and Reference Scenarios

	Albemarle Land-River Segment (A51003JL1_6770_6850)			Charlottesville Land-River Segment (A51540JL1_6770_6850)		
Landuse Group	Baseline (acres)	Reference (acres)	**Change as % of Total Area**	Baseline (acres)	Reference (acres)	**Change as % of Total Area**
Conv. Tillage - no manure	294.8	259.2	**-0.037%**	0.0	0.0	**0.000%**
All Other Row Crops	107.0	100.1	**-0.007%**	0.0	0.0	**0.000%**
Pasture	9,044.3	7,611.3	**-1.486%**	0.0	0.0	**0.000%**
Hay	5,899.2	6,231.5	**0.345%**	0.0	0.0	**0.000%**
Forest	68,717.9	70,069.2	**1.401%**	593.5	593.5	**0.000%**
Impervious Urban	2,624.0	2,427.2	**-0.204%**	1,477.3	1,366.6	**-1.687%**
Pervious Urban	8,640.2	8,837.0	**0.204%**	4,452.9	4,563.6	**1.687%**
Extractive	219.4	11.2	**-0.216%**	0.0	0.0	**0.000%**
Nursery	15.8	15.8	**0.000%**	0.0	0.0	**0.000%**
Water	870.7	870.7	**0.000%**	37.1	37.1	**0.000%**
Total Area	**96,433.2**	**96,433.2**		**6,560.8**	**6,560.8**	

Table 5-6. Percent Change in Land Use Category Distribution within Each Group between Baseline and Reference Scenarios

Landuse Group	Component Landuses in each Group	Albemarle Land-River Segment			Charlottesville Land-River Segment		
		Baseline (% of Group)	Reference (% of Group)	**Change as % of Baseline***	Baseline (% of Group)	Reference (% of Group)	**Change as % of Baseline***
Conv. Tillage - no manure	%hom	95.9%	0.0%	**-100.0%**	0.0%	0.0%	
	%nho	4.1%	100.0%	**2339.0%**	0.0%	0.0%	
All Other Row Crops	%hwm	46.6%	0.0%	**-100.0%**	0.0%	0.0%	
	%nhi	2.0%	10.0%	**402.0%**	0.0%	0.0%	
	%lwm	49.3%	0.0%	**-100.0%**	0.0%	0.0%	
	%nlo	2.1%	90.0%	**4169.8%**	0.0%	0.0%	
Pasture	%pas	93.3%	87.5%	**-6.3%**	0.0%	0.0%	
	%npa	4.0%	12.2%	**208.2%**	0.0%	0.0%	
	%trp	2.7%	0.3%	**-88.8%**	0.0%	0.0%	
	%afo	0.0%	0.0%		0.0%	0.0%	
Hay	%hyw	72.3%	0.0%	**-100.0%**	0.0%	0.0%	
	%nhy	3.1%	62.7%	**1929.7%**	0.0%	0.0%	
	%alf	2.1%	0.0%	**-100.0%**	0.0%	0.0%	
	%nal	0.1%	1.8%	**1929.7%**	0.0%	0.0%	
	%hyo	22.5%	35.5%	**57.9%**	0.0%	0.0%	
Forest	%for	99.0%	99.0%	**0.0%**	99.0%	99.0%	**0.0%**
	%hvf	1.0%	1.0%	**-1.9%**	1.0%	1.0%	**0.0%**
Impervious Urban	%rid	29.2%	29.2%	**0.0%**	99.9%	99.9%	**0.0%**
	%nid	70.8%	70.8%	**0.0%**	0.1%	0.1%	**0.0%**
Pervious Urban	%rpd	43.5%	43.2%	**-0.7%**	99.4%	99.4%	**0.0%**
	%npd	54.5%	54.9%		0.1%	0.1%	
	%rcn	1.9%	1.9%	**-2.2%**	0.5%	0.5%	**-2.4%**

* Not calculated when Baseline = 0.

Table 5-7. Local Land Use Areas (acres) Distributed to Bay Model Categories - Reference Scenario

	Lodge Creek		Moores Creek*		Schenks Branch		Meadow Creek*	
P532 Landuse Name	**003 (acres)**	**540 (acres)**	**003 (acres)**	**540 (acres)**	**003 (acres)**	**540 (acres)**	**003 (acres)**	**540 (acres)**
high-till without manure	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
high-till without manure NM	0.0	0.0	60.1	0.0	0.0	0.0	0.0	0.0
high-till with manure	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
high-till with manure NM	0.0	0.0	1.0	0.0	0.0	0.0	0.7	0.0
low-till with manure	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
low-till with manure NM	0.0	0.0	9.2	0.0	0.0	0.0	6.6	0.0
hay with nutrients	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
hay with nutrients NM	0.0	0.0	487.4	0.0	0.0	0.0	19.8	0.0
alfalfa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
alfalfa NM	0.0	0.0	14.1	0.0	0.0	0.0	0.6	0.0
hay without nutrients	0.0	0.0	275.9	0.0	0.0	0.0	11.2	0.0
pasture	0.0	0.0	173.3	0.0	0.0	0.0	10.7	0.0
pasture NM	0.0	0.0	24.3	0.0	0.0	0.0	1.5	0.0
pasture corridor	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0
animal feeding operations	0.0	0.0	4.4	0.0	0.0	0.0	0.5	0.0
forest	6.8	43.0	13,004.5	159.9	0.6	52.3	426.8	231.5
harvested forest	0.1	0.4	128.5	1.6	0.0	0.5	4.2	2.3
regulated impervious developed	10.7	107.5	301.7	596.8	0.3	473.2	214.3	605.1
nonregulated impervious developed	26.0	0.1	731.8	0.6	0.7	0.4	519.9	0.6
regulated pervious developed	27.1	213.1	1,953.1	1,126.8	5.2	861.2	521.6	1,121.6
nonregulated pervious developed	34.4	0.2	2,480.8	1.0	6.6	0.8	662.6	1.0
regulated construction	1.2	1.1	85.0	5.6	0.2	4.3	22.7	5.6
atmospheric deposition	0.0	0.0	227.7	4.7	0.6	1.3	9.3	9.7
Total Area (acres)	**106.2**	**365.3**	**19,963.4**	**1,897.1**	**14.1**	**1,394.0**	**2,433.1**	**1,977.5**
Watershed Area Totals	**471.4**		**21,860.5**		**1,408.1**		**4,410.6**	

* Moores Creek excludes Lodge Creek; Meadow Creek excludes Schenks Branch.

5.5. Land-Based Load Calculation

Unit-area loads (UALs) were calculated from the CBWM Phase 5.3.2 edge-of-stream (eos) output by dividing long-term average annual sediment (TSS) load by the applicable area. UALs were calculated for each of the 23 land-based land use categories within each of the two applicable land-river segments, as shown in Table 5-8 for the Baseline scenario.

Table 5-8. Sediment (TSS) Unit-Area Loads (UALs) for Applicable Land-River Segments - Baseline Scenario

		TSS (tons/ac/yr)**	
P532 Landuse Code	**P532 Landuse Name**	**Albemarle 003**	**Charlottesville 540**
hom	high-till without manure	0.14	
nho	high-till without manure NM	0.14	
hwm	high-till with manure	0.11	
nhi	high-till with manure NM	0.11	
lwm	low-till with manure	0.07	
nlo	low-till with manure NM	0.07	
hyw	hay with nutrients	0.04	
nhy	hay with nutrients NM	0.04	
alf	alfalfa	0.04	
nal	alfalfa NM	0.04	
hyo	hay without nutrients	0.04	
pas	pasture	0.95	
npa	pasture NM	0.96	
trp	pasture corridor	11.86	
afo	animal feeding operations	3.08	
for	forest	0.03	0.11
hvf	harvested forest	0.20	0.78
rid	regulated impervious developed	0.81	0.90
nid	nonregulated impervious developed	0.81	0.90
rpd	regulated pervious developed	0.13	0.14
npd	nonregulated pervious developed	0.13	0.14
rcn	regulated construction	2.35	3.50
atdep	atmospheric deposition	0.00	0.00

** Landuses without UAL values were not represented in these segments.

The load for an individual land use in each watershed was calculated by multiplying the applicable unit-area load with its corresponding area in each portion of the watershed, and then summing. The loads from all land uses were calculated in a similar fashion and then summed for a total load from each watershed. This procedure was used twice: once for calculating existing or baseline loads, and a second time for calculating reference or TMDL allocated loads. The baseline loads were based on output from the VAST 2009 Progress

(2010 Landuses) scenario, while the reference loads were based on output from the final VAST WIP1-VA scenario.

Portions of each of the four impaired watersheds comprise the majority (85.9%) of the City of Charlottesville land-river segment. Therefore, as further justification for the appropriateness of this application for local conditions, the following comparison was made between the local area and UAL method used in this TMDL and the areas and loads used for the City of Charlottesville land-river segment, as shown in Table 5-9. For the local area and UAL method, areas and loads were aggregated from each watershed portion within the City of Charlottesville. While the local area-UAL method produced slightly larger loads for each model run, the overall percent reduction was slightly lower than using the CBWM output. While the local area-UAL method is not meant to produce output identical to the CBWM model output, this comparison is made to show the similarity in areas, loads, and percent reductions between the 2009 baseline and the WIP model runs for the land-based sources, with the variations attributable to the identified differences in local landuses.

Table 5-9. Comparison of CBWM Output and the Local Area-UAL Method for the City of Charlottesville Land-River Segment (A51540JL4_6520_6710)

	Area (acres)	TSS (tons/yr)	% Reduction
Land-river segment: A51540JL4_6520_6710 (Moores Creek WWTP load not included)			
Baseline	**6,560.8**	**2,088.71**	
TMDL	**6,560.8**	**1,787.23**	**14.4%**
Impaired Watersheds: Local Landuse-Based Calculation (excludes Moores Creek WWTP load)			
Baseline			
Lodge Creek	365.3	136.72	
Moores Creek	1,897.1	741.56	
Schenks Branch	1,394.0	574.44	
Meadow Creek	1,977.5	756.30	
Baseline Totals	**5,633.8**	**2,209.02**	
TMDL			
Lodge Creek	365.3	120.01	
Moores Creek	1,897.1	650.05	
Schenks Branch	1,394.0	502.74	
Meadow Creek	1,977.5	663.69	
TMDL Totals	**5,633.8**	**1,936.49**	**12.3%**
Impaired Watersheds as % of Land-river segment	85.9%		

5.6. Non-Land Based Load Representation

5.6.1. Animal Feeding Operations (afo)

In the CBWM Phase 5.3.2, the area assigned to the "afo" land use category was based on an inventory of the number and type of livestock operations. In the CBWM, this information was obtained by county from the Agricultural Census data, calculated as a density (number/acre) and then multiplied by the area of each land-river segment within the county. As a first estimate for the study watersheds, these same densities were also applied to the area of each impaired watershed within each land-river segment. However, since this estimate relied on an even distribution of the livestock farms across each county, a more specific inventory of livestock operations in each impaired watershed was used to refine the Census estimates.

The 2007 Agricultural Census reported no livestock operations within the City of Charlottesville, with the majority of the pasture areas located in the Albemarle portion of Moores Creek. Since the StreamWatch organization recently created a GoogleMap overlay of the Rivanna River Basin to inventory beef and dairy operations, this source was used to refine our estimate of the number of farms in each of the four impaired watersheds. Based on this inventory, 7 cattle farms were identified in Moores Creek-003 and 1 farm in Meadow Creek-003 watershed portions. These numbers were used to revise the numbers for the "Cattle and Calves Farms" farm type in Table 5-10.

Table 5-10. Calculation of afo Areas

Farm Type	Moores Creek - 003		Meadow Creek - 003	
	No. of Farms	afo acres	No. of Farms	afo acres
Cattle and Calves Farms	7	3.5	1	0.5
Hog and Pig Farms	0	0	0	0
Poultry Farms	2.7	0.675	0	0
Sheep and Lambs Farms	2	0.2	0	0
Milk goats farms	0.5	0.025	0	0
Angora Goats farms	0.3	0.015	0	0
Total afoacres		4.415		0.5

In the CBWM, the numbers of each type of livestock operation were then multiplied by the "afo acres/farm type", which are constant values by farm type as derived for the CBWM (USEPA, 2010a), to calculate the "afoacres" in each watershed. There were no farms in either Lodge Creek or Schenks Branch watersheds. For the Reference scenario, the "afoacres" were adjusted based on the percent change in this land use category between the Baseline and Reference model runs for the Albemarle County model segment.

5.6.2. Sanitary Sewer Overflows (SSOs)

Sanitary sewer overflows are non-permitted releases of untreated or partially treated sewage that occur generally during rainfall-runoff events due to undersized pipes, blockages, power outages to pumping stations, or groundwater infiltration into sewer lines. These typically occur at manholes or pumping stations, although they can also take the form of backups into buildings and private residences. SSOs are not included explicitly in the CBWM, because of the highly variable nature of these sources. However, since data are available locally to estimate the loads resulting from this source, loads from this source have been added to the existing baseline scenario. The data used to estimate the volume of flows from SSOs came from DEQ's Pollution Response Program (PReP), based on municipal- and citizen-reported incidences of spills that entered surface waters. In addition to the reported incidences with flow into surface waters as shown in Table 5-11, there were numerous other spills on the land surface that did not run off to surface waters. In order to calculate baseline loads, the average annual quantity of SSO releases was calculated by watershed from July 2006 through April 2011, and multiplied by the average TSS concentration reported by the Moores Creek Sewage Treatment Plant (STP) for 6 overflow events from 2009-2011 (69.17 mg/L). The average annual quantity and sediment loads from SSOs are reported in Table 5-12.

For the Reference scenario, SSOs were assumed to be eliminated.

Table 5-11. DEQ PReP Reported Incidences of SSOs

Date Reported	Site Name	Site Address	Watershed	Quantity in Water (gallons)
07/13/06	City of Charlottesville	Cleveland Ave-Stadium Road	Lodge Creek	1,800
10/16/09	City of Charlottesville	100 Harmon St	Lodge Creek	1,000
11/12/09	City of Charlottesville	5th St SW heavily wooded area, MH 14-001 and 21-404	Lodge Creek	1,500
11/13/09	City of Charlottesville	Hartmans Mill Rd MH21-382 and 21-381	Lodge Creek	1,500
11/19/09	City of Charlottesville	100 Harmon St, MH 20-016	Lodge Creek	1,000
11/19/09	City of Charlottesville	1033 5th St SW, MH 13-018	Lodge Creek	2,000
11/19/09	City of Charlottesville	5th St SW, MH 21-404	Lodge Creek	2,500
11/19/09	City of Charlottesville	Brookwood Dr, MH 13-367	Lodge Creek	1,000
11/19/09	City of Charlottesville	5th St SW, MH 13-006	Lodge Creek	500
11/19/09	City of Charlottesville	Behind Old Fifth Cir, MH 14-005B	Lodge Creek	1,500
12/03/09	City of Charlottesville	5th St SW	Lodge Creek	500
12/03/09	City of Charlottesville	5th St SW, MH 13-002	Lodge Creek	1,000
12/09/09	City of Charlottesville	McIntire Rd MH 07-037	Lodge Creek	1,500
12/09/09	City of Charlottesville	5th St Circle MH 14-005B	Lodge Creek	1,000
12/09/09	City of Charlottesville	5th St SW, MH 13-018, 13-367, 13-004, & 13-002	Lodge Creek	1,500
12/09/09	City of Charlottesville	5th St., Heavily wooded area MH 14-001	Lodge Creek	1,000
09/02/07	Albemarle Co. Service Auth.	195 Woodlake Dr	Meadow Creek	500
06/01/09	Flooded Basement	2209 N. Burkshire Rd.	Meadow Creek	300
11/19/09	City of Charlottesville	Barracks Rd, MH 22-206	Meadow Creek	1,000
12/27/10	Albemarle County Service Authority (unpermitted)	495 Brookway Dr	Meadow Creek	1,000
12/20/06	Moores Creek WWTP	Just West of the #1 Chlorine contact basin	Moores Creek	2,000
02/13/07	Moores Creek WWTP	Headworks of the plant	Moores Creek	1,000
09/02/07	Albemarle Co. Serv. Auth.	226 Blackthorn Ln	Moores Creek	500
11/02/09	City of Charlottesville	5th St. Southwest in heavily wooded area, MH 14-001	Moores Creek	1,000
11/19/09	Moores Creek WWTP	695 Moores Creek Ln	Moores Creek	83,000
01/17/10	Rivanna Water & Sewer	MH along 36 " bypass line to holding pond, located below #1 eq. basin.	Moores Creek	90,000
01/26/10	Moores Creek WWTP VA0025518	695 Moores Creek Lane-outfall 002	Moores Creek	3,142,000
02/28/11	Moores Creek Reg. STP VA0025518	Hillside northwest of RWSA Admin Building	Moores Creek	28,800
11/19/09	City of Charlottesville	McIntire Rd, MH 07-037	Schenks Branch	1,000
01/25/10	City of Charlottesville	5th St SW wooded area , MH# 14-001 & 21-404	Lodge Creek	1,500

Table 5-12. Summary of SSO Annual Average Quantities and Sediment Loads, 07/06 – 04/11

Watershed	Quantity in Water (gallons)	Average Quantity (gal/yr)	TSS Load (lbs/yr)
Lodge Creek	22,300	4,812.0	2.78
Meadow Creek	2,796	603.3	0.35
Moores Creek	3,348,297	722,511.6	417.07
Schenks Branch	999	215.6	0.12

5.6.3. Permitted Point Sources

There are two VPDES permit holders within the study watershed boundaries, although only one facility has a TSS monitoring requirement. The existing load from the facility with TSS monitoring requirements was based on reported average flow and TSS concentrations from monthly Discharge Monitoring Reports submitted to DEQ, while loads under the Reference scenario were based on the average daily flow and TSS concentration included as permit limits. Current and permitted flows, concentrations, and sediment loads for the VPDES facilities are reported in Table 5-13.

Table 5-13. Summary VPDES Current and Permitted Flows, Concentrations, and Loads

Facility Name	VPDES Permit Number	Baseline Conditions			Reference Conditions			Watershed
		Current Average Flow (MGD)	Current Average [TSS] (mg/L)	**Current TSS Load (lbs/day)**	Permitted Average Flow (MGD)	Permitted Average [TSS] (mg/L)	**Permitted TSS Load (lbs/day)**	
Moore's Creek STP	VA0025518	9.3	6.2	**481**	15	22	**2,756**	Moores Cr.
Virginia Oil	VA0087351	0.0010	--	**--**	0.0073	--	**--**	Schenks Br.

5.6.4. Stormwater Runoff

Urban/residential areas are represented in the CBWM as a combination of pervious and impervious areas. Sediment loading outputs from the model are reported as aggregate loads from the various types of permitted and non-permitted, pervious and impervious urban sources of stormwater runoff. There are several types of permitted stormwater runoff sources in the watersheds. These include industrial stormwater permits and Virginia Stormwater Management Program (VSMP) permits, which include permits for industrial runoff from construction sites and Municipal Separate Storm Sewer System (MS4) permits for urbanized areas and public facilities and roads. Phase II of Section 402(p) of the Clean Water Act was an expansion of the MS4 program to cover stormwater discharges from urban areas serving populations less than 100,000 and from construction sites that disturb one to five acres.

There are 2 general wastewater permits and 7 industrial stormwater discharge permits in the watersheds. Both types of permits are subject to industrial stormwater discharge permit limits. Stormwater discharge permits carry a maximum permitted TSS concentration of 100 mg/L. Industrial stormwater loads were simulated as part of the regulated pervious developed (rid) and regulated pervious developed (rpd) landuses, and are encompassed by one of the MS4 entities. Since the MS4 load within each watershed is already an aggregated value, the industrial stormwater TSS loads may also be considered to be an aggregate load within each watershed, encompassed within the MS4 aggregate load.

The VSMP permits are for control of erosion and sediment on construction sites and the location of disturbed areas will change from year to year as some construction is completed and other begun. Loads from these sources were included in the simulated loads from urban pervious areas are also encompassed within the aggregate MS4 load in each watershed. The current list of VSMP construction permits is shown in Table 5-14, with total disturbed areas of 89.80 acres in Moores Creek (excluding Lodge Creek), 6.8 acres in Lodge Creek, 58.56 acres in Meadow Creek (excluding Schenks Branch), and 15.61 acres in Schenks Branch.

Table 5-14. Summary of VSMP Permits and Disturbed Areas

VAR Permit Number	Activity Name	Receiving Water(s)	Est Project Start Date	Est Project End Date	Total Land Area (ac)	Disturbed Area (ac)
Moores Creek Permits						
VAR10-10-101860	Avon Park Subdivision	Biscuit Run UT (Moores Cr.)	01-Jan-07		5	5
VAR10-11-100521	Piedmont Virginia Community College - Parking Lot Expansion - Commercial	Biscuit Run/Moores Creek	11-Oct-10	30-Jan-11	2.1	2.1
VAR10-10-100232	Claude Moore Medical Education Building Project	Moores Creek	01-Jan-08	30-Apr-10	1.1	1.1
VAR10-10-101226	Habitat for Humanity - Nunley St.	Moores Creek	15-Sep-07	31-Dec-10	2.7	2.2
VAR10-10-100506	Huntley Subdivision PUD	Moores Creek	03-Jan-04	03-Jan-11	22.8	17.1
VAR10-10-103459	Moores Creek Wastewater Treament Plant - Industrial Infrastructure; Expansion/Improvements of a Wastewater	Moores Creek	01-Sep-09	30-Jun-14	89.5	12
VAR10-10-102595	Piedmont Virginia Community College	Moores Creek	10-Nov-08	11-Mar-10	37.43	2.7
VAR10-10-100019	Ragged Mountain Water main replacement Phase 2 and 3	Moores Creek	20-Apr-09	20-Oct-09	1.4	1.4
VAR10-10-100581	Sieg Warehouse	Moores Creek	27-Mar-09	24-Jul-09	2.9	1.76
VAR10-10-100864	South Lawn Project	Moores Creek	01-May-07		0	5.5
VAR10-11-100543	Stadium Road Sanitary Sewer Collector Rehabilitation Phase II & III - Municipal Sanitary Sewer Replacement/Upgrade	Moores Creek	01-Oct-10	31-Aug-11	11.1	11.1
VAR10-10-104400	University of Virginia - University Data Center - Commercial	Moores Creek	01-Apr-10	01-Apr-10	1.3	1.3
VAR10-10-101429	Forest Hill Park	Moores Creek UT	18-May-09	18-Dec-09	7.4	5.9
VAR10-10-100907	UVA - CAS and ITE Buildings	Moores Creek UT	24-Nov-08	01-Dec-11	3.9	3.9
VAR10-10-101452	UVA Long Term Acute Care Hospital	Morey Creek UT (Moores Cr.)	17-Feb-09	10-Sep-10	8.5	2.6
VAR10-10-102277	Brookwood	Rock Creek (Moores Cr.)	01-Aug-06	30-Jul-10	12.72	12
VAR10-10-103169	Rock Creak Villages - Residential	Rock Creek (Moores Cr.)	30-Sep-09	01-Jan-11	4.05	1.05
VAR10-10-102980	Buford Middle School Campus	Rock Creek UT (Moores Cr.)	01-Jun-09	01-Sep-10	18.09	1.09
Lodge Creek Permits						
VAR10-10-104882	University of Virginia - Alderman Road Housing Phase III Utilities	Lodge Creek	24-May-10	11-Aug-10	2.2	2.2
VAR10-10-102543	University of Virginia	Lodge Creek	30-Jun-09	30-Aug-12	4.6	4.6
Meadow Creek Permits						
VAR10-10-103013	Meadow Creek Parkway Replacement - Sewer Replacement/Upgrade	Meadow Creek	01-Aug-09	01-Dec-10	5.09	5.09
VAR10-10-104009	Meadow Creek Sanitary Sewer Interceptor Upgrade Design - Contract B - Sewer Replacement/Upgrade	Meadow Creek	01-Dec-09	30-Dec-11	13.15	13.15
VAR10-10-104086	St. Anne's - Belfield School - Commercial	Meadow Creek	01-Apr-09	30-Sep-10	13.7	13.7
VAR10-10-102424	UVA - Bavaro Hall	Meadow Creek	01-May-08	15-May-10	2.38	2.38
VAR10-10-103872	Abbington Crossing - Clubhouse Replacement - Replacement of an Existing Apartment Clubhouse, Swimming Pool & Playground	Meadow Creek UT	19-Oct-10	31-May-10	2	0.8
VAR10-10-103802	Hillsdale Drive Extended - Commercial	Meadow Creek UT	01-Nov-09	01-May-10	14.6	8.3
VAR10-10-104445	Red Lobster - Commercial Construction of a New Restaurant	Meadow Creek UT	15-Mar-10	30-Jun-10	2.13	2.5
VAR10-11-100300	Treesdale Park - Residential	Meadow Creek UT	15-Aug-10	15-Aug-11	6.6	5.9
VAR10-10-103098	University of Virginia - Band Rehearsal Hall - Educational Bldg - New Construction	Meadow Creek UT	10-Nov-09	01-Dec-10	1.05	1.05
VAR10-10-103803	Whole Foods Market - Commercial	Meadow Creek UT	01-Nov-09	01-May-10	3.76	4.09
VAR10-10-101596	Northfields	Town Branch Creek (Meadow Cr.)	23-Mar-09	30-Sep-09	13.5	1.6
Schenks Branch Permits						
VAR10-10-104284	Wellington Court - Residential	Schenks Branch	01-Jun-11	01-Jul-12	1.4	1.3
VAR10-10-104008	Meadow Creek Sanitary Sewer Interceptor Upgrade Design - Contract A - Sewer Replacement/Upgrade	Schenks Branch/Meadow Creek	01-Dec-09	30-Apr-11	14.31	14.31

There are four Phase II MS4 stormwater permits that overlap the four impaired watersheds, belonging to Albemarle County, the City of Charlottesville, the University of Virginia, and the Virginia Department of Transportation (VDOT). In addition, a fifth MS4 permit for Piedmont Virginia Community College is wholly within Albemarle County MS4 within Moores Creek watershed. Loads from these sources are also included in the urban loads in the Bay model output and, because their boundaries are intermingled, are aggregated in the TMDL. A map of the respective boundary areas (which approximate their MS4 drainage areas) and how they intersect the four watersheds is shown in Figure 5-1. Additional information for consideration and use by local stakeholders for determining the distribution of aggregate MS4 waste load allocations amongst jurisdictions is included in Appendix A.

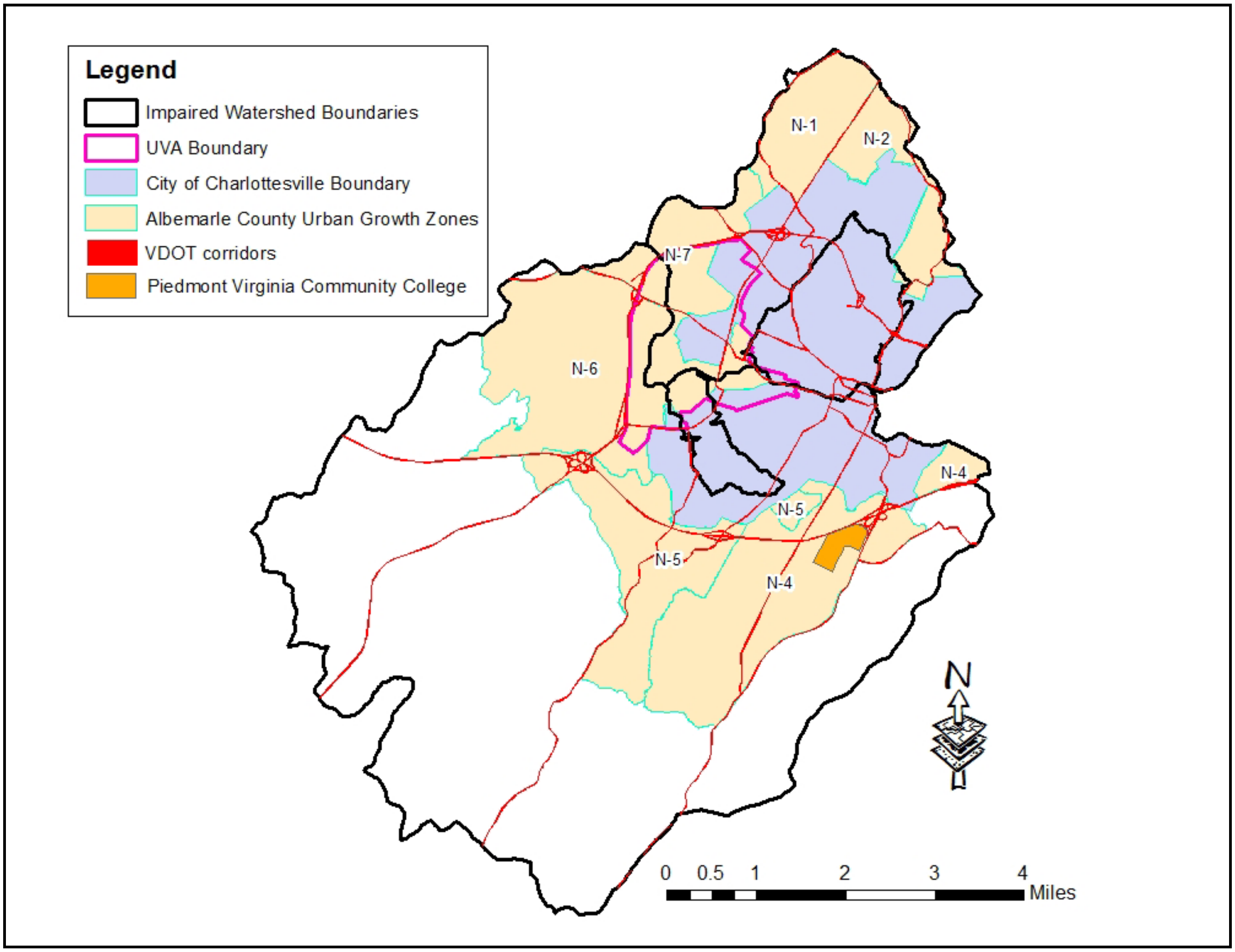

Figure 5-1. Approximate MS4 Areas within the Impaired Watersheds

5.7. Reassessment of the Moores Creek Impaired Stream Segment

DEQ's delineation procedures for stream segments corresponding to biological monitoring stations, defines the impaired segment as the entire stream segment from the nearest major upstream confluence to the nearest major downstream confluence. In the case of Moores Creek, the portion of the impaired stream segment downstream from the monitoring point receives discharge from the Moores Creek WWTP. Since this discharge is downstream from the biological monitoring point, it does not contribute to the identified upstream impairment. However, since it contributes discharge to the overall impaired stream segment, its existing and permitted TSS loads traditionally would get factored into the overall existing and TMDL loads for the watershed. However, since the WWTP is discharging well below its permitted TSS load limit, incorporating the difference between its current TSS load (87.7 tons/yr) and its permitted annual load (503.1 tons/yr) would require load reductions from other sources in the watershed, over and above those required at the identified point of impairment.

A discussion about the impairment delineation was held between representatives of DEQ's permit, assessment, and TMDL staff to explore a more reasonable approach to address this issue. The agreed upon solution was to base sediment load calculations only on those portions of the watershed upstream from the 2-MSC000.60 biological monitoring station, pending concurrence by EPA. A delineation of the new watershed boundary for Moores Creek reduces the watershed area used to calculate sediment loads by a very small amount (48.4 ha), and eliminates the additional load reductions that would be necessitated by including the WWTP permitted load. Since the WWTP already has a sediment WLA as part of the larger Rivanna River Benthic TMDL, it is not being excluded from the TMDL process, but is being represented more appropriately in a larger watershed where it is actually upstream from an impairment. This approach will exclude the WWTP from the Moores Creek, Lodge Creek, Meadow Creek, and Schenks Branch TMDLs and IP. The remainder of the TMDL analysis and calculations described in this report are based on this new watershed boundary.

CHAPTER 6: TMDL ALLOCATIONS

The objective of a TMDL is to allocate allowable loads among different pollutant sources so that appropriate actions can be taken to achieve water quality standards (USEPA, 1991). The stressor analysis indicated that sediment was the “most probable (pollutant) stressor” in all four watersheds, although hydrologic modification was also cited as a non-pollutant stressor in three of the four watersheds, primarily related to the large amounts of impervious surfaces in those watersheds. Since TMDLs are typically only developed for pollutant stressors, sediment will serve as the basis for development of the TMDL in each watershed.

6.1. Sediment TMDLs

6.1.1. Baseline and Reference Loads

Load calculations were performed on each of the four watersheds by CBWM source category under both Baseline (existing) conditions and Reference (TMDL) conditions in the Phase 5.3.2 CBWM. These TMDLs are being developed for sediment. Since many of the CBWM land use categories within a CBWM group relate to nutrient management or have similar sediment transport and delivery mechanisms, the land use/source categories were simplified by grouping all of the hay land uses together into “hay” and the pasture and pasture nutrient management categories into “pasture”. Additionally, urban land use categories were consolidated into “pervious urban”, “impervious urban”, and “construction” categories. Although Phase 5.3.2 includes MS4 sub-categories for each of the urban categories, the distribution of MS4 loads in the TMDLs were based on pervious and impervious areas identified from the local land use inventory. English units of acres and tons are used to report areas and simulated sediment loads, respectively, in this report. Tables 6-1 through 6-4 list the CBWM source categories, associated areas (acres) and sediment loads (tons/yr) for

Lodge Creek, Moores Creek, Schenks Branch, and Meadow Creek, respectively. The Landuse/Source category and load cells are color-coded in the following tables using the same Groups of landuses used in Chapter 5.

Table 6-1. Lodge Creek: Areas and Corresponding Sediment Loads for Baseline (2009) and Reference (TMDL) Conditions

CBWM Landuse/Source Category	Baseline Scenario		Reference Scenario	
	Area (acres)	TSS (tons/yr)	Area (acres)	TSS (tons/yr)
forest	49.9	4.8	49.8	4.7
harvested forest	0.5	0.4	0.5	0.2
impervious developed	146.7	128.5	144.2	109.9
pervious developed	272.0	37.1	274.7	32.8
construction	2.3	6.6	2.2	6.5
combined sewer overflows and SSOs		0.0002		0.00
Average Annual Sediment Load		**177.4**		**154.1**
			Overall Reduction =	**14.0%**

Table 6-2. Moores Creek: Areas and Corresponding Sediment Loads for Baseline (2009) and Reference (TMDL) Conditions

CBWM Landuse/Source Category	Baseline Scenario		Reference Scenario	
	Area (acres)	TSS (tons/yr)	Area (acres)	TSS (tons/yr)
conventional tillage - no manure	60.6	8.2	60.1	6.3
high-till cropland	5.0	0.5	1.0	0.1
low-till cropland	5.3	0.4	9.2	0.6
hay	781.4	30.2	777.3	26.7
pasture, other	197.5	188.0	197.5	128.8
pasture corridor	5.5	65.5	0.6	7.1
animal feeding operations	4.4	13.6	4.4	8.4
forest	13,086.6	435.6	13,138.9	437.3
harvested forest	131.9	27.2	129.9	23.5
impervious developed	1,653.4	1,391.0	1,629.3	1,164.8
pervious developed	5,555.2	724.4	5,541.2	608.9
construction	92.8	224.2	90.2	218.1
combined sewer overflows and SSOs		0.02		0.0
point source discharges		0.0		0.0
Average Annual Sediment Load		**3,109.0**		**2,630.8**
			Overall Reduction =	**16.2%**

Table 6-3. Schenks Branch: Areas and Corresponding Sediment Loads for Baseline (2009) and Reference (TMDL) Conditions

CBWM Landuse/Source Category	Baseline Scenario		Reference Scenario	
	Area (acres)	TSS (tons/yr)	Area (acres)	TSS (tons/yr)
forest	53.1	5.5	52.9	5.5
harvested forest	0.5	0.4	0.5	0.2
impervious developed	485.0	435.9	474.6	376.4
pervious developed	863.0	119.6	873.7	107.5
construction	4.6	15.8	4.5	15.6
combined sewer overflows and SSOs		0.00001		0.00
Average Annual Sediment Load		**577.3**		**505.2**
			Overall Reduction =	**13.4%**

Table 6-4. Meadow Creek: Areas and Corresponding Sediment Loads for Baseline (2009) and Reference (TMDL) Conditions

CBWM Landuse/Source Category	Baseline Scenario		Reference Scenario	
	Area (acres)	TSS (tons/yr)	Area (acres)	TSS (tons/yr)
forest	655.0	38.1	658.3	38.2
harvested forest	6.6	2.7	6.6	1.5
high-till with manure nutrient management	3.6	0.4	0.7	0.1
low-till with manure nutrient management	3.8	0.3	6.6	0.4
hay	31.6	1.2	31.6	1.1
pasture	12.5	15.6	12.3	8.4
animal feeding operation	0.5	1.5	0.5	1.0
impervious developed	1,356.4	1,151.9	1,339.9	972.1
pervious developed	2,292.9	305.8	2,306.8	264.5
construction	28.9	74.3	28.3	72.9
combined sewer overflows and SSOs		0.00002		0.0
Average Annual Sediment Load		**1,591.9**		**1,360.1**
			Overall Reduction =	**15.4%**

6.1.2. Sediment TMDLs

The sediment TMDL for each watershed was calculated, and its components distributed, using the following equation:

$$TMDL = \sum WLA + \sum LA + MOS + FG$$

where $\sum WLA$ = sum of the wasteload (permitted) allocations;

$\sum LA$ = sum of load (nonpoint source) allocations;

MOS = margin of safety; and

FG = future growth allocation.

The TMDL load in each impaired watershed corresponds to the average annual sediment load, based on loads generated using the Virginia Watershed Implementation Plan scenario (WIP1-VA) and the CBWM. The WIP1-VA scenario incorporates BMP implementation percentages proposed by the state for achieving load reductions at the outlet of each downstream tidal segment, as identified in the Chesapeake Bay TMDL.

The waste load allocation (WLA) consisted of the aggregated loads for the various MS4 jurisdictions (including an aggregated WLA for construction permits), the loads from permitted facilities, and the aggregate allocation for animal feeding operations, where applicable. There are currently five MS4 permits in the study area (Albemarle County, City of Charlottesville, University of Virginia, Virginia Department of Transportation, and Piedmont Virginia Community College). In most cases, MS4 areas overlap or are intertwined and currently the boundaries of these systems are not geospatially defined, making disaggregation of the MS4 loads to individual jurisdictions difficult. EPA, DEQ, and DCR support the aggregation of MS4 WLAs for this reason. Additionally, aggregation encourages stakeholder cooperation and facilitates implementation of appropriate BMPs to address reductions required by the TMDL. The TMDL will be revisited in the future as new information warrants.

An implicit MOS was assumed in the sediment TMDL, as conservative parameter values and estimates of BMP efficiencies were used as inputs, and cumulative sediment loads resulting from the Bay-wide TMDL (reference) scenario met the applicable water clarity water quality standard in all segments of the Chesapeake Bay. Although the Chesapeake Bay estuarine model actually showed that no decrease was needed in sediment loads to achieve the light and turbidity standards, since phosphorus decreases were necessary, an explicit MOS of 19% was applied to sediment loads delivered to the tidal segments to represent the associated decreases in sediment from needed phosphorus reductions. However, since sediment is the focus of these TMDLs and the waters of concern are local and analogous to the EOS scenarios, the explicit MOS was not considered to be applicable. Furthermore, total watershed loads, calculated by the disaggregate method in this study, are based on the CBWM model, which was calibrated to in-stream loads, thereby producing loads that are more realistic in magnitude and less in need of an explicit MOS to ensure that simulated loads will provide an adequate basis for meeting water quality objectives.

After projecting future land use changes in each watershed, simulated changes in load showed slight variations, which on average, equaled approximately 1% of the TMDL load. The local Steering Committee recommended simplifying the load allocations for future growth (FG) to 1% of the TMDL load for each watershed.

The LA was calculated as the TMDL minus the sum of MOS, WLA, and FG. The TMDL load, components, and individual and aggregated WLAs are shown for each watershed in Table 6-5.

Table 6-5. Sediment TMDLs and Components (tons/yr) for Lodge Creek, Moores Creek, Schenks Branch, and Meadow Creek

Watershed	TMDL	WLA		LA	MOS	FG
Lodge Creek	154.1	147.0		5.6	Implicit	1.5
		VAR040051 City of Charlottesville VAR040074 Albemarle County VAR040073 University of Virginia VAR040115 Virginia DOT construction Aggregate WLA = 6.5 tons/yr	147.0			
Moores Creek*	2,630.8	1,010.5		1,594.0	Implicit	26.3
		VAR040051 City of Charlottesville (includes VAG111032) VAR040074 Albemarle County (includes VAR051960, VAR051387) VAR040073 University of Virginia VAR040115 Virginia DOT VAR040108 Piedmont Virginia Community College construction Aggregate WLA = 218.1 tons/yr	1,010.5			
Schenks Branch	505.2	499.3		0.8	Implicit	5.1
		VAR040051 City of Charlottesville (includes VAG110064) VAR040074 Albemarle County VAR040073 University of Virginia VAR040115 Virginia DOT construction Aggregate WLA = 15.6 tons/yr	499.3			
Meadow Creek*	1,360.1	1,309.5		37.0	Implicit	13.6
		VAR040051 City of Charlottesville (includes VAR050932) VAR040074 Albemarle County (includes VAR050876, VAR050974) VAR040073 University of Virginia (includes VAR051372) VAR040115 Virginia DOT construction Aggregate WLA = 72.9 tons/yr	1,309.5			

* Moores Creek excludes Lodge Creek; Meadow Creek excludes Schenks Branch.

6.2. Allocation Scenarios

The target load for the allocation scenario in each watershed is the TMDL minus the sum of MOS and FG. The MOS was determined to be implicit and the FG was represented as 1% of the TMDL load to account for future growth. The target loads, therefore, were equal to 99% of the TMDL. New baseline scenarios were developed during Implementation Plan (IP) development based on the NoBMP scenario for the applicable CBWM land-river segments and BMPs were inventoried by the local jurisdictions to represent current conditions (Yagow et al., 2012b). The Allocation Scenarios, defined in the following tables, were the result of load reduction calculations based on the types and distributions of BMPs decided on by the local stakeholders that would most reasonably achieve water quality goals in each watershed. Although new areas of harvested forest and construction will require BMPs to address these transient sources of sediment, it was assumed that these sources are fairly constant and are already being addressed through the state's E&S Program and the Department of Forestry's regulatory requirements in the existing condition.

The following Allocation Scenario has been updated to correspond with the existing and planned BMP types and extents inventoried by the Local Steering Committee during IP development. Allocation scenarios are detailed in Table 6-6 through 6-9 for Lodge Creek, Moores Creek, Schenks Branch, and Meadow Creek, respectively.

Table 6-6. Lodge Creek: Sediment TMDL Load Allocation Scenario

CBWM Landuse/Source Category	Reference TMDL Scenario		New Baseline Scenario[1]		Allocation Scenario		
	Area (acres)	TSS (tons/yr)	Area (acres)	TSS (tons/yr)	Area (acres)	TSS (tons/yr)	% Load Reduction
forest	49.8	4.7	49.8	4.8	49.8	4.8	0.0%
harvested forest	0.5	0.2	0.5	0.2	0.5	0.2	
impervious developed	144.2	109.9	146.7	137.1	146.7	112.1	18.2%
pervious developed	274.7	32.8	272.0	36.2	272.0	29.0	20.0%
construction	2.2	6.5	2.3	6.6	2.3	6.6	0.0%
combined sewer overflows and SSOs		0.00		0.0002		0.00	100.0%
Average Annual Sediment Load		**154.1**		**184.8**		**152.6**	
Target Load (TMDL - FG) =		**152.6 tons/yr**					
Overall Reduction =				**17.4%**			

Table 6-7. Moores Creek: Sediment TMDL Load Allocation Scenario

CBWM Landuse/Source Category	Reference TMDL Scenario		New Baseline Scenario[1]		Allocation Scenario		
	Area (acres)	TSS (tons/yr)	Area (acres)	TSS (tons/yr)	Area (acres)	TSS (tons/yr)	% Load Reduction
conventional tillage - no manure	60.1	6.3	0.0	0.0	0.0	0.0	
high-till cropland	1.0	0.1	7.1	0.8	7.1	0.8	0.0%
low-till cropland	9.2	0.6	0.0	0.0	0.0	0.0	
hay	777.3	26.7	780.8	30.6	800.0	31.3	-2.4%
pasture, other	197.5	128.8	184.7	193.2	184.7	120.0	
pasture corridor	0.6	7.1	19.3	228.7	0.0	0.7	69.1%
animal feeding operations	4.4	8.4	4.4	14.0	4.4	14.0	
forest	13,138.9	437.3	13,206.8	439.6	13,206.8	439.6	0.0%
harvested forest	129.9	23.5	133.4	27.6	133.4	27.6	
impervious developed	1,629.3	1,164.8	1,654.6	1,390.0	1,654.2	1,261.1	9.3%
pervious developed	5,541.2	608.9	5,555.2	460.2	5,555.5	485.2	-3.7%
construction	90.2	218.1	92.8	224.2	92.8	224.2	
combined sewer overflows and SSOs		0.0		0.02		0.0	0.0%
Average Annual Sediment Load		**2,630.8**		**3,008.9**		**2,604.6**	
Target Load (TMDL - FG) =		**2,604.5**	**tons/yr**				
Overall Reduction =				**13.4%**			

* Moores Creek excludes Lodge Creek.

[1] 2010 landuse with RRBC pre2011 BMPs + E&S + Forest Harvesting BMPs

Table 6-8. Schenks Branch: Sediment TMDL Load Allocation Scenario

CBWM Landuse/Source Category	Reference TMDL Scenario		New Baseline Scenario[1]		Allocation Scenario		
	Area (acres)	TSS (tons/yr)	Area (acres)	TSS (tons/yr)	Area (acres)	TSS (tons/yr)	% Load Reduction
forest	52.9	5.5	53.1	5.5	53.1	5.5	0.0%
harvested forest	0.5	0.2	0.5	0.4	0.5	0.4	
impervious developed	474.6	376.4	485.0	467.9	485.0	425.1	8.0%
pervious developed	873.7	107.5	863.0	129.9	863.0	53.4	58.6%
construction	4.5	15.6	4.6	15.8	4.6	15.8	0.0%
combined sewer overflows and SSOs		0.00		0.00001		0.00	100.0%
Average Annual Sediment Load		**505.2**		**619.6**		**500.2**	
Target Load (TMDL - FG) =		**500.2**					
Overall Reduction =				**19.3%**			

[1] 2010 landuse with RRBC pre2011 BMPs + E&S + Forest Harvesting BMPs

Table 6-9. Meadow Creek: Sediment TMDL Load Allocation Scenario

CBWM Landuse/Source Category	Reference TMDL Scenario		New Baseline Scenario[1]		Allocation Scenario[2]		
	Area (acres)	TSS (tons/yr)	Area (acres)	TSS (tons/yr)	Area (acres)	TSS (tons/yr)	% Load Reduction
forest	658.3	38.2	654.2	38.1	654.2	38.1	0.0%
harvested forest	6.6	1.5	6.6	2.7	6.6	2.7	
high-till with manure nutrient manageme	0.7	0.1	7.3	0.9	7.3	0.9	0.0%
low-till with manure nutrient managemer	6.6	0.4	0.0	0.0	0.0	0.0	
hay	31.6	1.1	31.5	1.2	31.5	1.2	0.0%
pasture	12.3	8.4	12.5	19.9	12.5	19.9	0.0%
animal feeding operation	0.5	1.0	0.5	1.6	0.5	1.6	
impervious developed	1,339.9	972.1	1,356.6	939.2	1,356.6	939.2	0.0%
pervious developed	2,306.8	264.5	2,292.9	186.4	2,292.9	186.4	0.0%
construction	28.3	72.9	28.9	74.3	28.9	74.3	0.0%
combined sewer overflows and SSOs		0.0		0.00002		0.0	100.0%
Average Annual Sediment Load		**1,360.1**		**1,264.3**		**1,264.3**	
Target Load (TMDL - FG) =		**1,346.5**	**tons/yr**				
Overall Reduction =		**-6.5%**					

* Meadow Creek excludes Schenks Branch.

[1] 2010 landuse with RRBC pre2011 BMPs + E&S + Forest Harvesting BMPs

[2] No additional BMPs needed to achieve TMDL

6.3. Maximum Daily Loads for Sediment

The USEPA has mandated that TMDL studies submitted since 2007 include a maximum “daily” load (MDL), in addition to the average annual load shown in Section 6.1 (USEPA, 2006a). The approach used to develop the MDL was provided in Appendix B of a related USEPA guidance document (USEPA, 2006b). This appendix entitled “Approaches for developing a Daily Load Expression for TMDLs computed for Longer Term Averages” is dated December 15, 2006. This guidance provides a procedure for calculating an MDL (tons/day) for each watershed from the long-term average (LTA) annual TMDL load (tons/yr) and a coefficient of variation (CV) based on annual loads over a period of time. The “LTA to MDL multiplier” for each of the four watersheds was calculated from the 10 years of annual sediment loads used for calculation of the Chesapeake Bay TMDL (1991 - 2000) for their respective portions in the Albemarle land-river segment (A51003_JL1_6520_6710) and in the Charlottesville land-river segment (AZ51540_JL4_6520_6710). The coefficient of variation (CV) was calculated as the standard deviation divided by the average of the annual simulated sediment (TSSX) loads for each segment. The "LTA to MDL" multiplier was then interpolated using USEPA guidance. The MDL for each watershed was calculated as the TMDL divided by 365 days/yr and multiplied by the "LTA to MDL" multiplier. Since the WLA represents permitted loads, no multiplier was applied to these loads. Therefore the daily WLA and the daily FG were both converted to daily loads by dividing by 365 days/yr. The daily LA was calculated as the MDL minus the sum of the daily WLA and the daily FG. Measures of the annual TSS loads and the conversion factors are given in Table 6-10.

Table 6-10. TSS Annual Load Measures and Conversion Factors from Long-Term Average (LTA) to Maximum Daily Loads (MDL)

Annual Load Measures	**Albemarle Portion**	**Charlottesville Portion**	**Units**
Average Annual Load	11,526.0	1,564.0	tons/yr
Standard Deviation	9,422.0	551.1	tons/yr
Minimum	3,726.9	751.6	tons/yr
Maximum	37,020.2	2,378.9	tons/yr
Coefficient of Variation	0.82	0.35	
"LTA to MDL" Multiplier	5.674	2.458	
Based on Table B-1 (USEPA, 2006a)			

The resulting MDLs and associated components for each of the four watersheds are shown in Table 6-11 in units of tons/day. Expressing the TMDL as a daily load does not interfere with a permit writer's authority under the regulations to translate that daily load into the appropriate permit limitation, which in turn could be expressed as an hourly, weekly, monthly or other measure (USEPA, 2006a).

Table 6-11. Maximum "Daily" Sediment Loads and Components (tons/day) for Lodge Creek, Moores Creek, Schenks Branch, and Meadow Creek

Watershed	MDL	WLA		LA	MOS	FG
Lodge Creek	1.34	0.40		0.93	Implicit	0.004
		VAR040051 City of Charlottesville VAR040074 Albemarle County VAR040073 University of Virginia VAR040115 Virginia DOT construction Aggregate WLA = 0.018 tons/day	0.40			
Moores Creek*	35.17	2.77		32.33	Implicit	0.07
		VAR040051 City of Charlottesville (includes VAG111032) VAR040074 Albemarle County (includes VAR051960, VAR051387) VAR040073 University of Virginia VAR040115 Virginia DOT VAR040108 Piedmont Virginia Community College construction Aggregate WLA = 0.598 tons/day	2.77			
Schenks Branch	3.42	1.37		2.04	Implicit	0.01
		VAR040051 City of Charlottesville (includes VAG110064) VAR040074 Albemarle County VAR040073 University of Virginia VAR040115 Virginia DOT construction Aggregate WLA = 0.043 tons/day	1.37			
Meadow Creek*	15.29	3.59		11.67	Implicit	0.04
		VAR040051 City of Charlottesville (includes VAR050932) VAR040074 Albemarle County (includes VAR050876, VAR050974) VAR040073 University of Virginia (includes VAR051372) VAR040115 Virginia DOT construction Aggregate WLA = 0.2 tons/day	3.59			

* Moores Creek excludes Lodge Creek; Meadow Creek excludes Schenks Branch.

CHAPTER 7: TMDL IMPLEMENTATION

The goal of the TMDL program is to establish a three-step path that will lead to attainment of water quality standards. The first step in the process is to develop TMDLs that will result in meeting water quality standards. This report represents the culmination of that effort for the benthic impairments on Lodge Creek, Moores Creek, Schenks Branch, and Meadow Creek. The second step is to develop a TMDL implementation plan. The final step is to implement the TMDL implementation plan and to monitor stream water quality to determine if water quality standards are being attained.

Once a TMDL has been approved by USEPA and then the State Water Control Board (SWCB), measures must be taken to reduce pollutant levels in the stream. These measures, which can include the use of better treatment technology and the installation of BMPs, are implemented in an iterative process that is described along with specific BMPs in the implementation plan. The process for developing an implementation plan has been described in the "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the DEQ and DCR TMDL project staff or at http://www.deq.state.va.us/tmdl/implans/ipguide.pdf. With successful completion of implementation plans, Virginia begins the process of restoring impaired waters and enhancing the value of this important resource. Additionally, development of an approved implementation plan will improve a locality's chances for obtaining financial and technical assistance during implementation.

DCR and DEQ will work closely with watershed stakeholders, interested state agencies, and support groups to develop an acceptable implementation plan that will result in meeting the water quality target in each watershed. The delisting of each impaired stream segment, however, will be based on biological health and not on numerical pollution loads.

7.1. Staged Implementation

Implementation of BMPs in these watersheds will occur in stages. The benefit of staged implementation is that it provides a mechanism for developing public support and for evaluating the efficacy of the TMDL in achieving the water quality standard.

In general, Virginia intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. Among the sediment sources identified in these four watersheds, the following BMPs should be useful in effecting the necessary reductions: livestock stream exclusion, riparian buffers, grazing land management, animal feeding operation management, improved erosion and sediment (E&S) management, street sweeping, and urban infiltration and detention BMPs.

The iterative implementation of BMPs in the watershed has several benefits:

1. It enables tracking of water quality improvements following BMP implementation through follow-up stream monitoring;
2. It provides a measure of quality control, given the uncertainties inherent in computer simulation modeling;
3. It provides a mechanism for developing public support through periodic updates on BMP implementation and water quality improvements;
4. It helps ensure that the most cost effective practices are implemented first; and
5. It allows for the evaluation of the adequacy of the TMDL in achieving water quality standards.

Watershed stakeholders have had an opportunity to participate in the development of the TMDL implementation plan. Specific goals for BMP implementation were established as part of the implementation plan development.

7.2. Link to ongoing Restoration Efforts

Implementation of this TMDL will contribute to on-going water quality improvement efforts in these four watersheds. Ongoing restoration efforts include the Meadow Creek Stream Restoration project which is being coordinated with a Rivanna Water and Sewer Authority project to upgrade a Sanitary Sewer Interceptor along the stream; existing MS4 programs in Albemarle County, the City of Charlottesville, the University of Virginia, the Piedmont Virginia Community College, and along VDOT properties; incorporation of urban infiltration practices, such as the rain garden in Greenleaf Park; constructed wetlands for a 40-ac residential area and a 4-ac wetland included in the mitigation plan for Ragged Mountain Dam, both within the Moores Creek watershed; and retrofitting green roofs on existing municipal buildings, such as the Charlottesville City Hall and the Police Building. In addition, efforts will be made to learn from, and coordinate with, other existing TMDLs for bacteria and sediment in the Rivanna River Basin and the Moores Creek Bacteria TMDL Implementation Plan (RRBC, 2012).

7.3. Reasonable Assurance for Implementation

7.3.1. TMDL Monitoring

DEQ will continue monitoring benthic macroinvertebrates and habitat at the following stations in accordance with its biological monitoring program: 2-XRC001.15, 2-MSC000.60, 2-SNK000.88, and 2-MWC000.60. TSS will be monitored at the same set of stations in accordance with DEQ's ambient monitoring program, with the exception of 2-XRC001.15. DEQ will continue to use data from these monitoring stations to evaluate improvements in the benthic community and the effectiveness of TMDL implementation in attainment of the general water quality standard.

7.3.2. TMDL Modeling

In parallel with the TMDL, a comparison study of the traditional reference watershed approach and the disaggregate method in several other watersheds was undertaken by Carlington Wallace as part of his master's thesis. Although unintentional in the original design of the research study, the reference watershed approach and the disaggregate method that were applied to the study watersheds by Wallace incorporated significant differences in representation of the watersheds from that used in the corresponding TMDLs and were not directly comparable. Wallace's parameterization for the disaggregate method was based on Phase 5.3 of the Chesapeake Bay Watershed Model which typically produced lower loads for all source sectors than did the Phase 5.3.2 version of the model, meaning that his reference loads were relatively lower, and causing his percent load reductions to be higher, than those reflected in the actual TMDL modeling. Then, the reference watershed approach typically is very conservative in its protection of water quality since the reference watershed has as a requirement that it is non-impaired, but the degree of its health has not typically been used to adjust the reference load to one that represents an exact threshold of impairment. And most importantly, Wallace's study was performed in isolation from the stakeholder community and did not benefit from the interaction with a technical advisory committee that provides feedback along the way during model development, as happened in the actual development of this TMDL. Therefore, the large differences shown between the two methods by Wallace are not an appropriate justification for adding an explicit MOS for these TMDLs. With the disaggregate method, the total watershed loads are based on a model calibrated to in-stream loads which should be more realistic in magnitude and less in need of an explicit MOS to ensure that simulated loads will provide an adequate basis for meeting water quality objectives. If in a future review, however, the reductions called for in these TMDLs based on current modeling are found to be insufficiently protective of local water quality, then revision(s) will be made as necessary to provide reasonable assurance that water quality goals will be achieved.

7.3.3. Regulatory Framework

Federal Regulations

While section 303(d) of the Clean Water Act and current USEPA regulations do not require the development of TMDL implementation plans as part of the TMDL process, they do require reasonable assurance that the load and wasteload allocations can and will be implemented. Federal regulations also require that all new or revised National Pollutant Discharge Elimination System (NPDES) permits must be consistent with the assumptions and requirements of any applicable TMDL WLA (40 CFR §122.44 (d)(1)(vii)(B)). All such permits should be submitted to USEPA for review.

State Regulations

Additionally, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (WQMIRA) directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters" (Section 62.1-44.19.7). WQMIRA also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. USEPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards.

For the implementation of the WLA component of the TMDL, the Commonwealth utilizes the Virginia NPDES program and elements of the Virginia Stormwater Management Program (VSMP), which typically include consideration of the WQMIRA requirements during the permitting process. Requirements of the permit process should not be duplicated in the TMDL process and implementation plan development, especially those implemented through water quality based effluent limitations. However, those requirements that are considered BMPs may be enhanced by inclusion in the TMDL IP, and their connection to the targeted impairment. New permitted point source discharges will be allowed under the waste load allocation provided they implement applicable VPDES requirements.

7.3.4. Implementation Funding Sources

Implementation funding sources will be determined during the implementation planning process by the local watershed stakeholder planning group with assistance from DEQ and DCR. Potential sources of funding include Section 319 funding for Virginia's Nonpoint Source Management Program, the U.S. Department of Agriculture's Conservation Reserve Enhancement and Environmental Quality Incentive Programs, the Virginia State Revolving Loan Program, and the Virginia Water Quality Improvement Fund, although other sources are also available for specific projects and regions of the state. The TMDL Implementation Plan Guidance Manual contains additional information on funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts.

7.3.5. Reasonable Assurance Summary

Watershed stakeholders will have opportunities to provide input and to participate in the development of the implementation plan, which will also be supported by regional and local offices of DEQ, DCR, and other cooperating agencies. For this set of impaired watersheds, DEQ has provided funding for implementation plan development, the results of which have been used to finalize the allocation scenarios presented in this report.

Once developed, DEQ intends to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e). In response to a Memorandum of Understanding (MOU) between USEPA and DEQ, DEQ also submitted a draft Continuous Planning Process to USEPA in which DEQ commits to regularly updating the WQMPs. Thus, the WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

Taken together, the follow-up monitoring, WQMIRA, public participation, the Continuing Planning Process, and the completed implementation plan

(Yagow et al., 2012b) comprise a reasonable assurance that the Lodge Creek, Moores Creek, Schenks Branch, and Meadow Creek sediment TMDLs will be implemented and water quality will be restored.

CHAPTER 8: PUBLIC PARTICIPATION

Public participation was elicited at every stage of the TMDL development in order to receive inputs from stakeholders and to apprise the stakeholders of the progress made. All Public Meetings and Technical Advisory Committee (TAC) meetings included presentations and discussions relevant to the impairment in all four watersheds.

A general information meeting was held on October 13, 2010 at the Thomas Jefferson Planning District Commission (TJPDC) Water Center Conference Room in Charlottesville, Virginia. The purpose of this meeting was to differentiate the TMDL study from a previous public meeting on a related water quality issue, to provide an overview of the impaired stream segments and the TMDL process, and to discuss the results of a series of polycyclic aromatic hydrocarbon (PAH) measurements that had been collected in response to concerns raised at the fore-mentioned public meeting. This informational meeting was attended by 18 people.

The first TAC meeting was held on December 9, 2010 in the TJPDC Water Center Conference Room, where the preliminary results from the stressor analysis were presented, and comments were solicited from the stakeholder group. The TAC meeting was attended by 18 people.

The first public meeting was held on January 6, 2011 at the Walker Upper Elementary School, 1564 Dairy Road in Charlottesville. At this meeting stakeholders from various environmental agencies and organizations were encouraged to share information about their organizations and activities in the impaired watersheds in the form of posters and displays. DEQ then presented an overview of the TMDL study process and some preliminary findings from the stressor analysis. The first public meeting was attended by 30 people.

A second TAC meeting was held on June 9, 2011 in the TJPDC Water Center Conference Room where the modeling procedures based on Chesapeake

Bay modeling outputs and calculation methodology were described and discussed. The second TAC meeting was attended by 22 people.

A third TAC meeting was held on July 7, 2011 in the TJPDC Water Center Conference Room where revisions of local inputs to the model were described and discussed. The third TAC meeting was attended by 20 people.

A fourth TAC meeting was held on August 18, 2011 in the TJPDC Water Center Conference Room where the draft TMDL report was presented and plans were made for the simplified public document and for the final public meeting prior to the initiation of the implementation planning process. The fourth TAC meeting was attended by 20 people.

A fifth TAC meeting was held on February 9, 2012 in the TJPDC Water Center Conference Room where an update on the draft TMDL report was presented including the latest revisions to load calculations, MS4 delineations, and planning for the final public meeting prior to the initiation of the implementation planning process. The fifth TAC meeting was attended by 17 people.

A public meeting to present the draft sediment TMDL reports for the Lodge Creek, Moores Creek, Schenks Branch, and Meadow Creek watersheds to address their benthic impairments was held on March 15, 2012 at CityScape in Charlottesville, Virginia. This final TMDL public meeting was attended by 19 stakeholders and served as the initiation of the TMDL implementation planning phase, which is a continuation of this project. The public comment period ended on April 14, 2012.

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Appendix A. Information for Consideration by Local Stakeholders for Distributing Aggregate MS4 Waste Load Allocations

Allocated MS4 waste loads have been provided to localities in aggregate to encourage cooperation among local stakeholders in arriving at the most equitable distribution of load reduction responsibilities. There are two types of information provided in this appendix which may be useful to local stakeholders for distributing responsibilities for loads and load reductions within the MS4 areas. The first type of information is area-based, considering the area of land subject to the MS4 and industrial wastewater permits in each watershed. The second type of information is load-based and is an estimate of existing and distributed TSS loads that gives some indication of the relative loading and reductions that might be associated with the various permits.

A summary of areas by permit within each watershed is given in **Error! Reference source not found.**. The MS4 areas are a subset of the jurisdictional boundary areas that include only pervious developed, impervious developed, and construction landuses. The University of Virginia and VDOT MS4 areas are subsets of the Albemarle County and City of Charlottesville MS4 areas. The VDOT area was estimated by buffering major roads with a 20-foot buffer within the County and City MS4 boundaries. The MS4 areas also include various other industrial stormwater runoff management permits that are listed under each MS4 entity.

Table A-1. Approximate MS4 and Industrial Stormwater Permit Areas (acres) within the Impaired Watersheds

MS4 Permit Numbers	MS4 Entity and Included VSMP Permits	Moores Creek*	Lodge Creek	Meadow Creek*	Schenks Branch	Total MS4 Areas
VAR040074	Albemarle County**	6,133.3	0.6	1,863.7	13.9	8,011.4
	VAR050876 Northrup Grumman			1.4		
	VAR050974 BFI Waste Services			1.3		
	VAR051960 Charlottesville Area Transit	4.4				
	VAR051387 Moores Creek Regional STP	85.0				
VAR040051	City of Charlottesville***	1,727.3	351.3	1,562.5	1,341.8	4,982.9
	VAG110064 Allied Concrete				8.0	
	VAG111032 HT Ferron	4.4				
	VAR050932 USPS			--		
	VAR051403 Charlottesville Transit Service				1.0	
VAR040073	University of Virginia (UVA)	646.8	116.4	910.2	23.9	1,697.3
	VAR051372 UVA Parking and Trans. Dept.			3.5		
VAR040115	Virginia Department of Transportation (VDOT)	140.3	3.1	74.2	28.5	246.2
VAR040108	Piedmont Virginia Community College (PVCC)	100.8				100.8
	Total MS4 Area (acres)	**8,748.5**	**471.4**	**4,410.6**	**1,408.1**	**15,038.7**

* Moores Creek excludes Lodge Creek; Meadow Creek excludes Schenks Branch.
** Albemarle County area excludes parts of UVA and VDOT areas and the PVCC area.
*** City of Charlottesville excludes parts of UVA and VDOT areas.

There are 2 general wastewater permits and 7 industrial stormwater discharge permits in the watersheds. These permits carry neither flow volume nor TSS concentration limits in their permits and were considered to be non-significant sources of sediment in the CBWM simulated scenarios. However, they were simulated as part of the regulated pervious developed (rid) and regulated pervious developed (rpd) landuses, and all fall within one of the MS4 entities. Existing TSS loads for these permits, shown in **Error! Reference source not found.**, were calculated from the UALs for the relevant portions of the rid and rpd landuses for either Albemarle County or the City of Charlottesville, except for permit VAR051960, which had monitored TSS concentrations for the load calculation. This permittee has already instituted a series of management practices to control its stormwater runoff, and local stakeholders are encouraged to account for other practices already in place, so that undue burden is not placed on those who have already made progress in runoff load reductions. Distributed TSS loads were calculated based on the drainage area of each permit, the permitted average TSS concentration and the average annual runoff, estimated using the Simple Method (Schueler, 1987). The Charlottesville Transit Service permit (VAR051403) received an existing load in **Error! Reference source not found.** since it was active during the time period when the impairment was identified, but not a distributed load in Table A-3, since the permit is no longer active.

Table A-2. Existing TSS Loads for Industrial Stormwater Permits

VPDES Permit Number	Facility Name	Source Type	Receiving Stream	MS4 Entity	Area (acres)	% Impervious	Maximum Monitored TSS (mg/L)	Existing TSS Load (tons/yr)*
VAR051960	Charlottesville Area Transit-Admin Maint and Oprtn	Industrial SW	Moores Creek UT	Albemarle	4.4	78.6	20.5	0.32
VAR051403	Charlottesville Transit Service	Industrial SW	Schenks Branch	Charlottesville	0.96	81.3		0.73
VAR051387	Moores Creek Regional STP	Industrial SW	Moores Creek	Albemarle	85	50		39.74
VAR051372	University of Va - Parking and Transportation Dept	Industrial SW	Meadow Creek	UVA	3.45	95		2.97
VAR050974	BFI Waste Servics LLC of Charlottesville	Industrial SW	Meadow Creek UT	Albemarle	1.3	90		0.96
VAR050932	USPS - Charlottesville Vehicle Maint Facility	Industrial SW	Meadow Creek UT	Charlottesville	No exposure			
VAR050876	Northrop Grumman Systems Corporation	Industrial SW	Meadow Creek UT	Albemarle	1.358	96.83		1.07
VAG111032	HT Ferron Company	wastewater*	Moores Creek UT	Charlottesville	4.44	77.5		3.23
VAG110064	Allied Concrete Company - Charlottesville	wastewater*	Schenks Branch UT	Charlottesville	8	90		6.58

* TSS Load for VAR051960 is based on maximum monitored TSS and average annual runoff calculated from the Simple Method (Schueler, 1987);
All other loads calculated from the unit-area loads for regulated impervious developed (rid) and regulated pervious development (rpd) landuses.

Table A-3. Distributed TSS Loads related to Industrial Stormwater Permit Concentrations

VPDES Permit Number	Facility Name	Source Type	Receiving Stream	MS4 Entity	Area (acres)	% Impervious	Permitted Average TSS Concentration (mg/L)	Average Annual Runoff (in/yr)	Distributed TSS Load (tons/yr)
VAR051960	Charlottesville Area Transit-Admin Maint and Oprtn	Industrial SW	Moores Creek UT	Albemarle	4.4	78.6	100	30.99	1.54
VAR051387	Moores Creek Regional STP	Industrial SW	Moores Creek	Albemarle	85	50	100	20.46	19.70
VAR051372	University of Va - Parking and Transportation Dept	Industrial SW	Meadow Creek	UVA	3.45	95	100	39.72	1.55
VAR050974	BFI Waste Servics LLC of Charlottesville	Industrial SW	Meadow Creek UT	Albemarle	1.3	90	100	35.18	0.52
VAR050932	USPS - Charlottesville Vehicle Maint Facility	Industrial SW	Meadow Creek UT	Charlottesville	No exposure		100	2.19	
VAR050876	Northrop Grumman Systems Corporation	Industrial SW	Meadow Creek UT	Albemarle	1.358	96.83	100	37.70	0.58
VAG111032	HT Ferron Company	wastewater*	Moores Creek UT	Charlottesville	4.44	77.5	100	32.81	1.65
VAG110064	Allied Concrete Company - Charlottesville	wastewater*	Schenks Branch UT	Charlottesville	8	90	100	37.75	3.42

* No effluent currently being discharged, so WLA is based solely on stormwater runoff.
Average Annual Runoff = Rv * annual precipitation, where Rv (Runoff Coefficient) = 0.050 + 0.009 * percent impervious
Annual precipitation = 40.91 inches (Albemarle County) and 43.89 (City of Charlottesville)
TSS Load (tons/yr) = X acres * Y mg/L * Z in/yr * 102,801.6 L/acre-inch * 1 lb/453,600 mg * 1 ton/2000 lbs = X * Y * Z * 0.000113317